DOCUMENT RESUME

ED 094 889 PS 007 446

AUTHOR	Nelson, Gordon K.
TITLE	Sensory-Motor and Verbal Foundations of Concept Acquisition: A Study in Early Childhood. Technical Report No. 272.
INSTITUTION	Wisconsin Univ., Madison. Research and Development Center for Cognitive Learning.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
PUB DATE	Aug 73
CONTRACT	NE-C-00-3-0065; OEC-5-10-154
NOTE	183p.; Report from the Program on Children's Learning and Development
EDRS PRICE	MF-$0.75 HC-$9.00 PLUS POSTAGE
DESCRIPTORS	Age Differences; Analysis of Variance; *Concept Formation; *Concept Teaching; Geometric Concepts; Graphs; Haptic Perception; Kinesthetic Perception; *Perceptual Motor Learning; *Preschool Children; Sex Differences; Tables (Data); Tactual Perception; Transfer of Training; *Verbal Learning; Visual Learning
IDENTIFIERS	Equilateral Triangle

ABSTRACT

A total of 100 3- and 5-year-old children were trained and assessed individually on the concept of equilateral triangle at three levels of attainment: concrete, identity, and classificatory. Five training conditions existed: (1) visual inspection; (2) visual inspection and verbal orienting instruction; (3) visual inspection, free haptic activity, and tactile-kinesthetic training; (4) visual inspection, free haptic activity, tactile-kinesthetic training, and verbal orienting instruction; and (5) unrelated play activity (control). Subjects were trained with 36 geometric blocks varying in shape, color, size, and thickness. After training, each subject's knowledge of the concept was tested at the three levels. Two sets of tasks were administered for testing: transfer of training using the training material as test stimuli and transfer of training using two-dimensional representations of geometric forms. The results indicated that: (1) there were transfer effects for both sets of tasks; (2) training conditions 2, 3, and 4 were more facilitating than 1 and 5; (3) condition 4 was most effective; (4) 5-year-old subjects performed better than 3-year-olds at each level; and (5) in some tasks, 3-year-old subjects did better when aided by manual activity and 5-year-old subjects performed better with verbal orienting instruction. Concluding discussion focuses on some theoretical and educational implications of the results. (Author/SDH)

AUG. 5 1974

PS

TECHNICAL REPORT

THE WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

The University of Wisconsin Madison, Wisconsin

U.S. Office of Education Center No. C-03 Contract [illegible]54

ED 094889

Technical Report No. 272

SENSORY-MOTOR AND VERBAL FOUNDATIONS OF CONCEPT ACQUISITION: A STUDY IN EARLY CHILDHOOD

Report from the Program on
Children's Learning and Development

by Gordon K. Nelson

Herbert J. Klausmeier
Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

August 1973

Published by the Wisconsin Research and Development Center for Cognitive Learning, supported in part as a research and development center by funds from the National Institute of Education, Department of Health, Education, and Welfare. The opinions expressed herein do not necessarily reflect the position or policy of the National Institute of Education and no official endorsement by that agency should be inferred.

Center Contract No. NE-C-00-3-0065

STATEMENT OF FOCUS

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints--financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

ACKNOWLEDGMENTS

The author wishes to express his deepest appreciation to:

Dr. Herbert J. Klausmeier, major professor and committee chairman, for his guidance, patience, and constructive criticism during the three years of graduate study and for working closely in the implementation and completion of this doctoral study;

Dr. Frank H. Hooper, committee reading member, for directing the author's graduate study in human development and for his introduction to the field of organismic developmental psychology;

Dr. Lawrence J. Hubert, committee reading member, for directing the author's graduate study in statistics and experimental design and for encouraging continued study in those areas;

Dr. Spencer S. Swinton and Dr. Steven M. Yussen for thoughtful comments while serving on the examination committee;

Dr. Benton J. Underwood for frequently consulting on experimental matters related to this study;

Mr. Hickory Hurie, director of Child Development Incorporated, and Mr. James Sendek, principal of Kegonsa Elementary School, for supplying subjects for this study;

The Wisconsin Research and Development Center for Cognitive Learning for providing virtually unlimited resources for the conduct of this study;

The author would also like to thank his wife, Nancy, and child, Shannon, for their love and understanding during the sometimes trying period of graduate study.

Table of Contents

List of Tables

List of Tables (continued)

List of Figures

ABSTRACT

One hundred children of 3- and 5-years of age were trained and assessed individually on the concept of equilateral triangle at three levels of attainment. Group 1 was asked to visually inspect geometric blocks which represented positive and negative instances of the concept. Group 2 was given verbal orienting instruction that called attention to relevant physical properties of the stimuli, along with visual inspection. Group 3 was given free haptic play and tactile-kinesthetic training with the stimuli to supplement visual inspection. Group 4 had a combination of manual activity and verbal instruction to supplement visual inspection. Group 5 engaged in unrelated play activity (control). The amount of time for training was equalized for the various conditions.

A day after training had been completed each subject's knowledge of the concept was tested at three levels: concrete, identity, and classificatory. The concrete level required discriminating and remembering positive instances of the concept. The identity level required discriminating and remembering positive instances when those instances were varied with respect to orientation and spatial context. The classificatory level required sorting of positive instances of the concept. Two sets of tasks were administered for testing: (1) transfer of training using the training materials as test stimuli, and (2) transfer of training using two-dimensional representations of geometric forms. Each task was scored for total number of correct responses.

The results indicated transfer effects for both sets of tasks. Training in Groups 2, 3, and 4 was significantly more facilitating to each of the three levels of concept attainment than training in Groups 1 and 5. Generally, the combination of manual activity and verbal orienting instruction with visual inspection (Group 4) was the most effective treatment condition. Five-year-old subjects performed significantly better than the 3-year-old subjects at each of the three levels of attainment. Predicted age x treatment interactions were not found to be significant at the designated level. However, on the concrete task using two-dimensional forms and on the two identity tasks using the training materials as test stimuli as well as the two-dimensional forms, 3-year-olds performed better when aided by a form of manual activity while 5-year-olds performed better when aided by verbal orienting instruction. Results of the study were discussed in terms of theoretical and educational implications.

Chapter I

INTRODUCTION

For over ten years now, one of the main lines of investigation at the Wisconsin Research and Development Center for Cognitive Learning has been the study of the process by which concepts are acquired, and the attendant internal and external conditions of learning that facilitate acquisition. Through systematically and carefully controlled experimentation, it has been possible to deduce the cognitive operations of concept learning, and, to date, a model has been formulated which describes the various operations at successively higher levels of inclusiveness and abstractness.

It is only befitting, therefore, that the present study, having grown from these very efforts, should be concerned with identifying internal and external conditions governing the early formation of concepts in children. The general purpose of the present study was to investigate the relative effects of sensory-motor and of verbal functions on concept learning in early childhood.

An overview of the model of conceptual learning and development (henceforth abbreviated CLD model) provides an appropriate framework for the present study. The CLD model was formulated initially by Klausmeier (1971) and refined by Klausmeier, Ghatala, and Frayer (in press). Figure 1 represents the levels of concept attainment and utilization as reported in the model, and the relationships between those levels. Four levels of concept attainment have been identified: concrete, identity, classificatory, and formal. Each successive level presumes mastery at an earlier given level. When a concept has been attained by a child at either the classificatory or formal levels, it may then be used to recognize supraordinate-subordinate relationships, cause and effect or correlative relationships, and may be used in understanding principles which in turn may be applied to problem-solving situations. The term "concept" is used here in designating a mental construct that an individual possesses.

Klausmeier, et al. (in press) indicate that early learning of concepts begins with perceptual encounters of concrete objects and events. Figure 2 shows the cognitive operations involved in acquiring a concept at the concrete level. One or more perceptual encounters with the same instance of a concept enables the child to identify that instance, usually a physical object although it might be a representation of the object, as a distinct entity and to discriminate it from other objects. When the child attends to the same perceptible instance, represents it internally and subsequently recognizes it as the same instance, he attains a concept of that particular instance. Thus, attaining the concrete level of a concept entails attending to a perceptible stimulus, discriminating the stimulus from other stimuli, and remembering the discriminated stimulus.

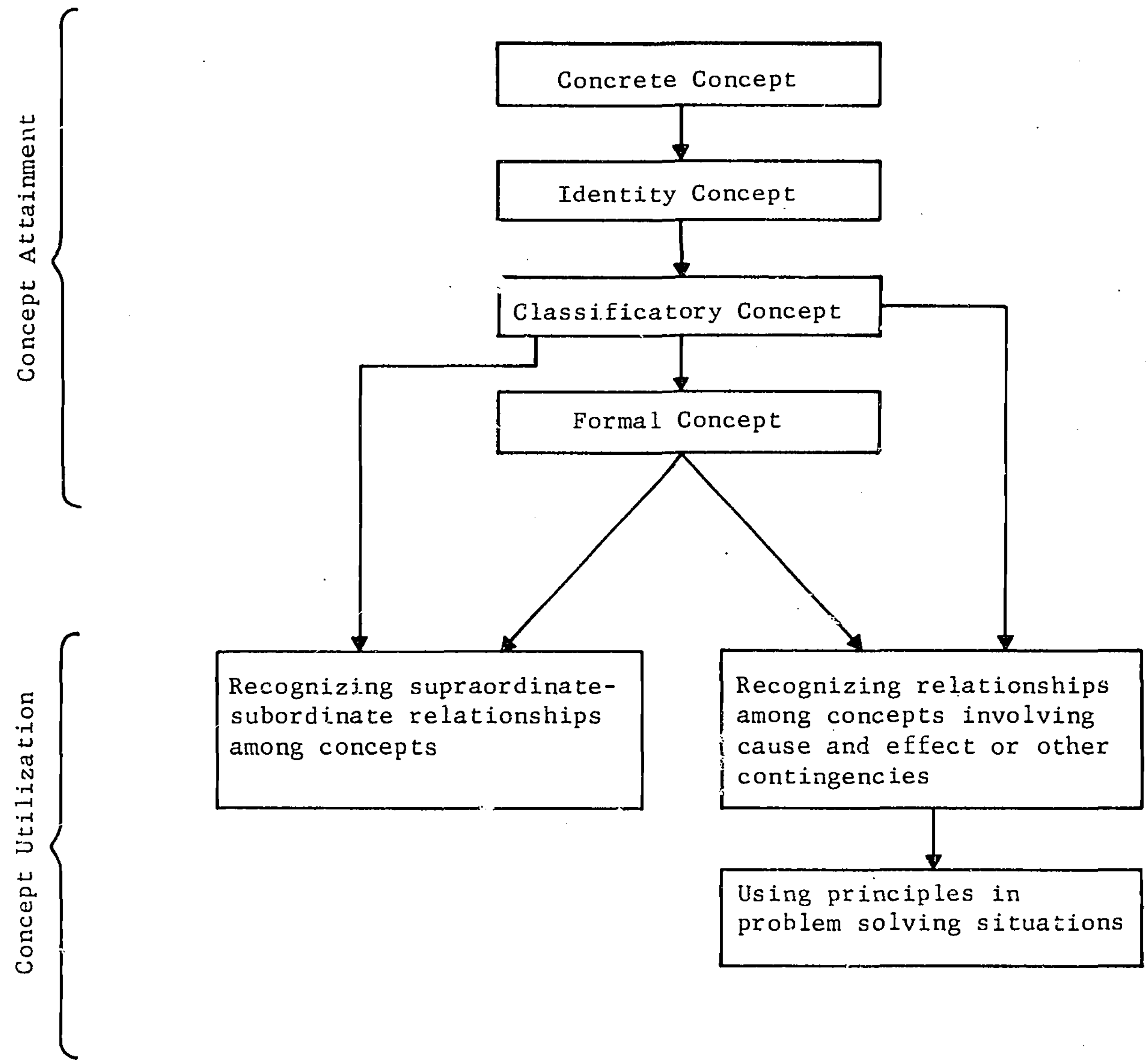


Figure 1. Levels of concept attainment and utilization (Based on Klausmeier, Ghatala, & Frayer, in press.)

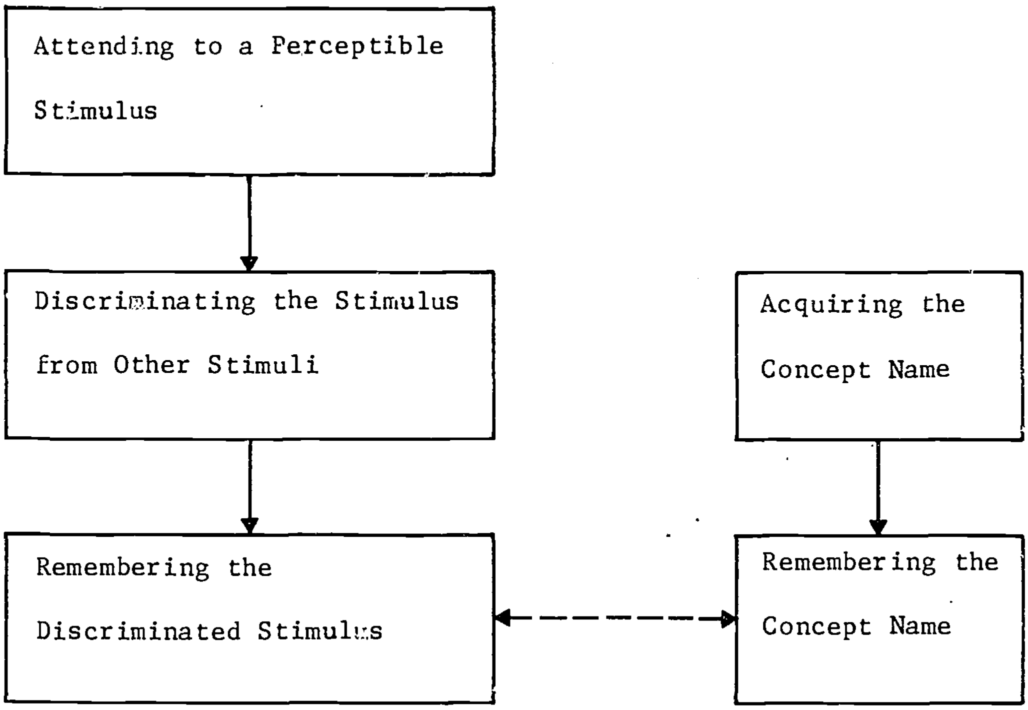


Figure 2. Cognitive operations entailed in reaching the concrete level of concept attainment (Based on Klausmeier, Ghatala, & Frayer, in press.)

A second level of attainment of the same concept is inferred when the child can identify a particular instance as the same one when the instance is in a different spatial context. This level is distinguised from the prior one in that the child not only discriminates objects from one another, but he also generalizes various forms of the object as the same. At this point the child has acquired a concept at the identity level. Figure 3 shows the cognitive operations entailed in acquiring a concept at this level.

Increased experience with concept instances soon enables a child to respond to two or more instances of the same class as equivalent. Figure 4 shows the cognitive operations entailed in reaching this level, the classificatory level, of attainment. The operations at this level are the same as the two lower levels with another operation being incorporated. The child must now generalize that at least two or more stimuli are equivalent in some way.

The highest level of concept attainment is inferred when the child can discriminate the attributes belonging to a class. Additionally, he can name the concept and the intrinsically defining attributes. Having acquired these operations, the child attains a concept at the formal level. Figure 5 shows the cognitive operations involved at this level of concept attainment. As it is noted in this figure, a child may infer the formal concept in either one of two ways: through cognizing common attributes from positive instances, or through

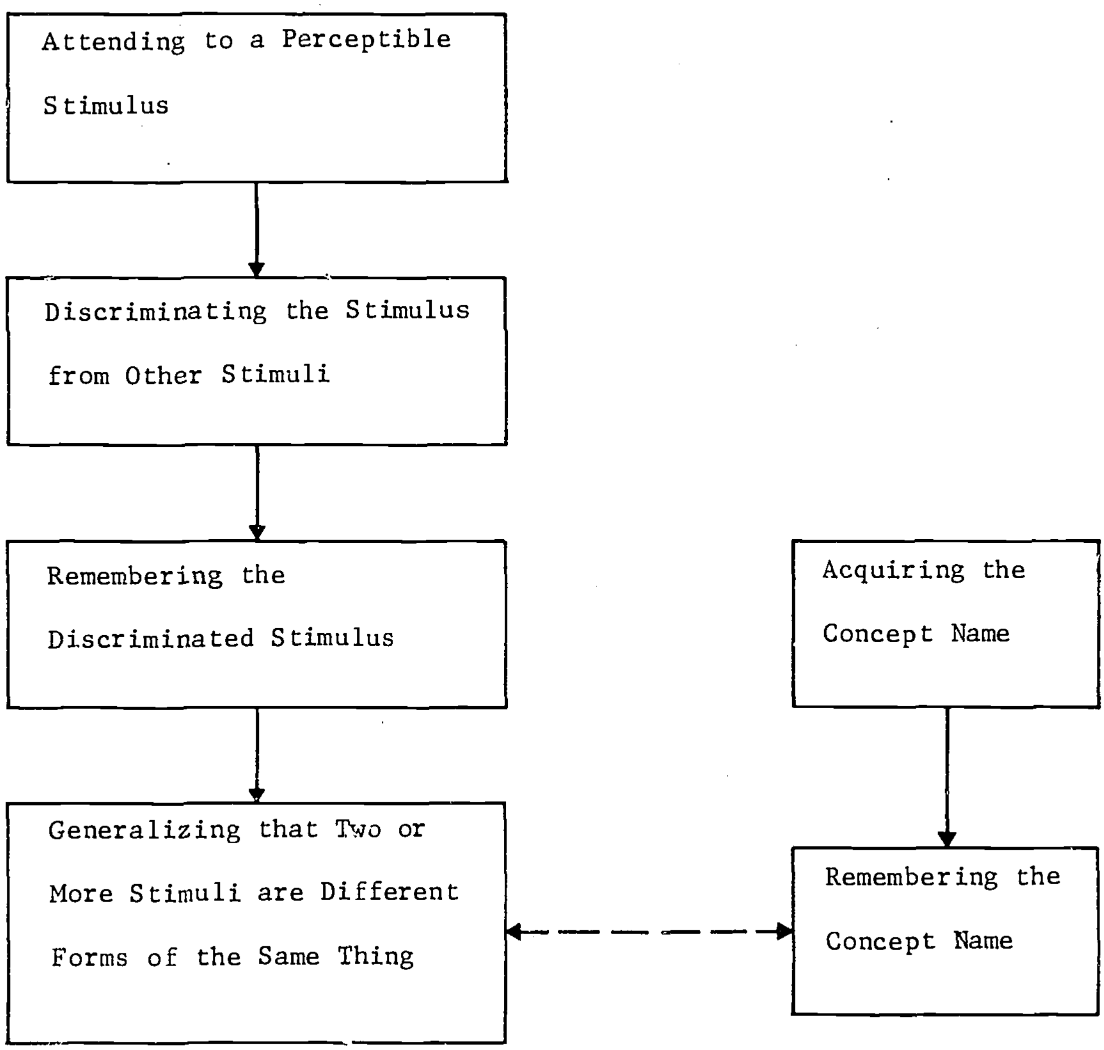


Figure 3. Cognitive operations entailed in reaching the identity level of concept attainment (Based on Klausmeier, Ghatala, & Frayer, in press.)

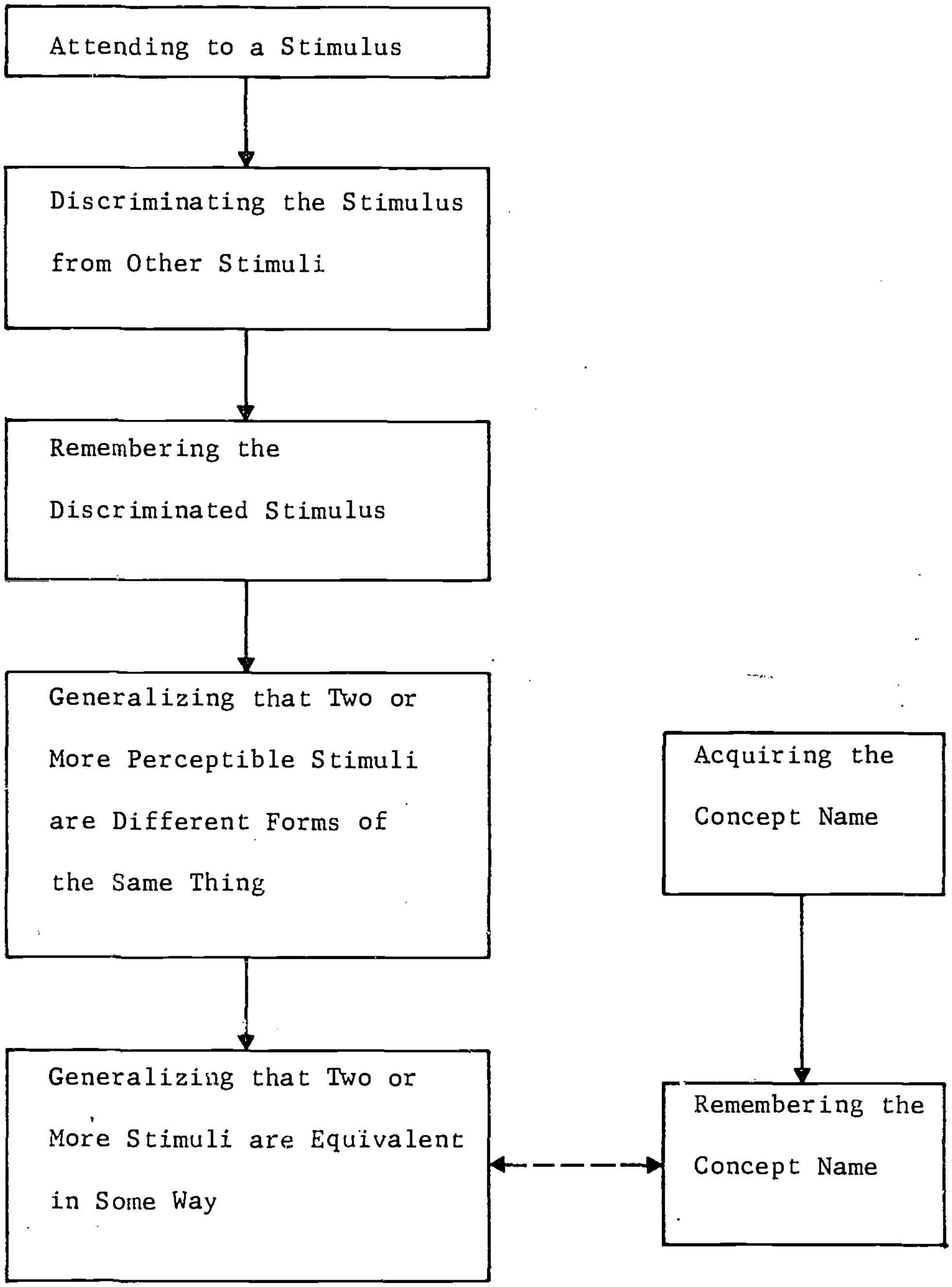


Figure 4. Cognitive operations entailed in reaching the classificatory level of concept attainment (Based on Klausmeier, Ghatala, & Frayer, in press.)

hypothesizing and evaluating of hypotheses.

In the present study, attention is focused exclusively on the concrete, identity, and classificatory levels of concept attainment. Children in the early childhood period are very likely to be engaged in concept activity related to these levels, and the effects of sensory-motor activity and verbal behavior (orienting instructions) often prove to be influencing. It is noted in the CLD model, however, that the chronological age at which concepts are acquired at successive levels may vary, depending upon the nature of the concept and the conditions of learning that an individual experiences.

Acquiring concepts at both the concrete and identity levels imply various forms of sensory-perceptual activity--including seeing, hearing, touching, etc. Analysis of the operations related to levels of concept attainment "is sufficiently comprehensive to include motoric experiencing of objects. . . The model postulates that attending, discriminating, and remembering are involved in motor as well as in perceptual [visual] experiences with objects, or sensorimotor experiencing . . . [Klausmeier, 1971, p. 2]." Not only does the model of cognitive operations in concept learning and development make provisions for sensory-motor experience at the nascent level of concept attainment, it acknowledges the instrumental function these experiences have at the higher level as well. "Thus, these forms of experiencing are applicable to the attainment of identity and rudimentary classificatory concepts and also to the attainment of formal concepts of the kind for which there are actual instances with intrinsic attributes [p.2.

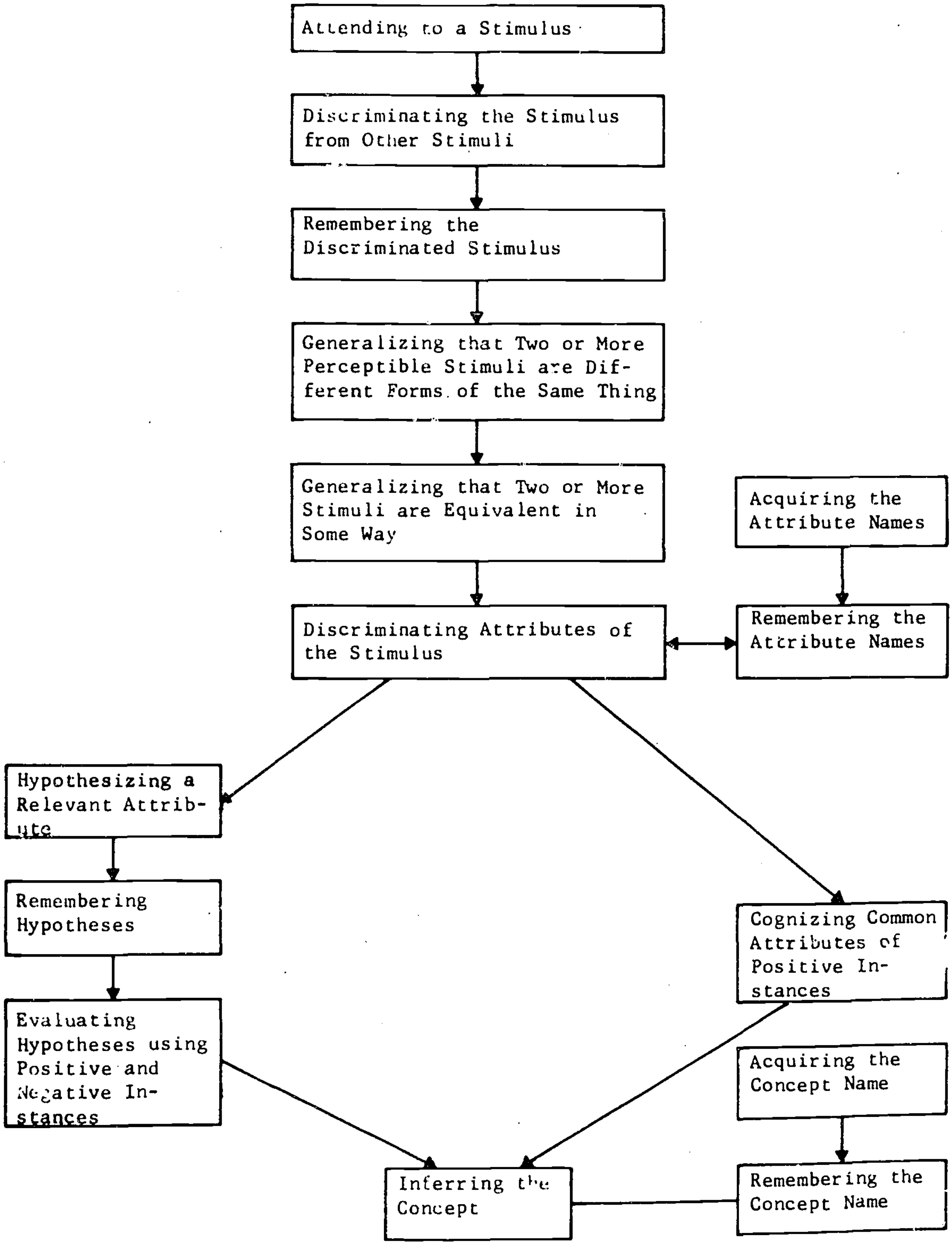


Figure 5. Cognitive operations entailed in reaching the formal level of concept attainment (Based on Klausmeier, Ghatala, & Frayer, in press.)

Language or verbalization is also regarded as having an important influence on concept attainment in the CLD model. Acording to Klausmeier, et al. (in press) language experience enables the child to attain concepts in the absence of perceptible instances. As is shown in Figures 2, 3, and 4, concept labels may be associated with attainment at any one of the three lower levels prior to the formation of a formal level concept. So that while having labels for concepts and attributes is prerequisite to attainment at the formal level, these labels may occur at the concrete, identity, or classificatory level as well.

The purpose of this study was to determine the relative effects of sensory-motor activity and verbal orienting instruction on concept attainment at the three lowest levels. Specifically, three basic questions were raised:

1. What are the effects of various combinations of visual inspection, sensory-motor training, and verbal orienting instruction on children's concept attainment at each of three levels--concrete, identity, and classificatory?
2. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to age?
3. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to sex?

The concept equilateral triangle was selected for study. One hundred children of ages 3- and 5-years were recruited from pre-school and kindergarten classrooms. Each S was randomly assigned to one of five treatment conditions. These included:

I. visual exploration

II. visual exploration + verbal orienting instruction

III. visual exploration + free haptic activity + tactile-kinesthetic training

IV. visual exploration + free haptic activity + tactile-kinesthetic training + verbal orienting instruction

V. control

Each experimental condition (with the exception of the control) involved one of these forms or combinations of sensory-motor and instructional input. The training materials consisted of 36 geometric blocks, and the amount of time devoted in attending to these materials was equalized for all conditions. After a S had received one of the five treatment or control conditions, his level of concept attainment was assessed at the concrete, identity, and classificatory levels. The Wisconsin R & D Center tasks developed by Frayer, Klausmeier, and Nelson (1973) and Klausmeier, Sipple, and Frayer (1973, in press) were used to assess mastery of the concept of equilateral triangle at these levels using two types of stimuli. The assessment stimuli consisted of the same 36 geometric blocks as were used in training (near transfer), and, in addition to this, two-dimensional drawings were used to represent these and other geometric forms (far transfer).

Examination of the three preceding questions provides a rationale for undertaking the research reported herein. The first question was raised for investigating the relative effects of type of training on concept acquisition. It was intended to ascertain the most facilitating methods of concept learning, whether it be visual, sensory-motor or verbal. As the reader will discover in Chapter II, very important theoretical questions have been raised recently concerning the relative effectiveness of visual and tactual (haptic, kinesthetic, etc.) modes for gathering information about objects. On the basis of conclusions reached in Chapter II, it was hypothesized for this study that Conditions II, III, and IV would be relatively more facilitating to early concept formation than Conditions I and V.

The CLD model holds that the effectiveness of these various influences depends on the level of concept attainment. Manipulative experiences are seen to be more facilitating at the lower levels, less facilitating at the higher levels. Thus, it was hypothesized that motor-related activity as entailed in Condition III would be more influential at the concrete and identity levels, while verbal orienting instruction as entailed in Condition II would be more influential at the classificatory level.

The second question deals with the main effect of age and a possible age x treatment interaction. It was hypothesized that the 5-year-olds would perform relatively better than the 3-year-olds at all three levels of concept attainment. In addition, it was expected that conditions emphasizing motor activity would be more helpful for the younger children than for the older children at these levels. Conversely, it was expected that conditions emphasizing verbal instruction and visual exploratory behavior would be more helpful for the older children than the younger children at these same levels.

The third question was included for the purpose of examining possible sex differences in type of training at each of the three levels of concept attainment. No hypothesis, however, was entertained with regard to sex differences.

Chapter II

REVIEW OF RELATED RESEARCH

Sensory-Motor Foundations of Cognitive Behavior

How does the young child understand the nature of objects? The proposition that sensory-motor functions underlie the child's understanding is not a new one to psychologists. Traditionally, infancy theorists (Gesell, 1949; Halverson, 1937; McGraw, 1943) have claimed that the child begins realizing the nature of objects by combining visual impressions together with tactual and kinesthetic impressions. This is said to occur in the first months of infancy when the child can direct his visual apparatus by grasping and manipulating objects. Piaget (1952) claims that intersensory connections or "schemata" form initially between vision and sucking, and later between vision and prehension, touch, kinesthetic impressions. The formation of these intercoordinated systems is deemed necessary for intellectual development.

While it always has been assumed that vision is functionally dependent upon touch as a means of gathering data about the world--at least ever since the 18th century philosopher Bishop Berkeley (1910) proposed that the visual derives its meaning from the tangible--results of recent experiments have brought this assumption under fierce attack (Bower, 1966; Bower, Broughton, & Moore, 1970; Rock & Victor, 1964; Rock & Harris, 1967). On the contrary, it has been recently argued that the sense of touch does not in any way guide or educate vision, but that vision is totally dominant over touch. Bower's experiments, for example, suggest that vision is well developed in the newborn child and that it is the primary information source about size, shape, and hardness of objects.

Still persisting are a number of unresolved questions of how sensory modes, particularly vision and touch, might complement one another's function in the pickup of stimulus information. One question eliciting considerable interest concerns the reciprocal relationship of the visual and tactile organs in young children's perception. In this section, major findings are summarized which bear on the relative roles played by touch and vision in perceptual learning and development, but first some working definitions appear necessary.

"Perception," functionally speaking, is simply the process by which we obtain direct, firsthand knowledge about the world. Information of this kind is channeled through one or more sense modalities (e.g., sight, hearing, touch), so that objects around the organism can be perceived in any combination of ways. There are a few terms that have been a source of general confusion which refer to some aspect of "touch." One of these is _haptic perception_, a term which accounts for sensory information derived by active _manual_ manipulation of objects. Another is _tactual perception_ which refers to sensory information obtained by _passive_ means, without active manual manipulation (e.g., touching an object to feel its texture). And a third is _kinesthetic perception_, used in this context for denoting the input of sensory information by _passive_ arm and hand movements, such as occur when an experimenter guides the hand of a subject over the path which defines a particular object (e.g., the perimeter of a triangular block). The reader is referred to a paper by J. Gibson (1962) who draws a number of careful distinctions between active and passive forms of touch.

The Piagetian Perspective

In Piaget's theory (Piaget, 1951, 1952, 1954, 1966, Piaget and Inhelder, 1967), sensory-motor activity is the most important governing factor in the formation of perceptual and intellectual structures. Perceptually, the young child gathers information of the world through the coordination of various centerings or "centrations" (momentary perceptual fixations) made upon some part of an object. Piaget illustrates the significance of sensory-motor experience in early perception:

> When the hand is centered on some part of an object, such as one of the angles of the cardboard triangle, it is obvious that the perception of this part of the surface, closed towards the point and open in the other direction, will automatically bring about a movement in the open direction, towards other parts of the triangle. . . But this same movement which will culminate in the exploration of the remaining angles of the triangle, itself reacts on the subsequent perception, since it 'transports' the data of the previous perception and on discovering a second angle will 'transpose' the earlier relationship on to the later ones. Thus the movement co-ordinates successive perceptions and constitutes the sum total of transformations ensuring the transition from one perception to another. . . From this standpoint there can be no perception which is not incorporated in a complex of sensori-motor activity [Piaget & Inhelder, 1967, pp. 38-39].

The dynamic psychic activity arising between subject and object has been a recurrent theme throughout the writings of Piaget. Knowledge, from Piaget's viewpoint, is abstracted from actions involving objects or their representation, from the coordination of actions through schemas, and not from objects alone. Consequently, the sensory-motor element (either on an overt level or in terms of the interiorized schema) underlies much of perceptual activity and is the basis upon which spatial notions are developed. When an object is removed from the child's view, he must recreate the motor components that produced the original percept through internalized imitation (mental imagery).

While sensory-motor activity is central to Piaget's theory, his discussions of it are generally confined to the first two years of life, or the sensory-motor period. Beyond this, he is chiefly concerned with the internalized representational aspects of preoperational thought, and still later, with aspects of concrete operational thought in which the child is no longer perception-bound. Occasional references are made to the role of overt sensory-motor activity in the young child's perceptual development.

For example, Piaget and Inhelder (1971) cite a study in which they asked children (4-6 years) to reproduce various kinetic sequences by manipulating two small 1 cm. cubes of wood. Each child executed these movements by retracing the path of the objects after (a) perceiving the sequence visually,and (b) perceiving the sequence by tactile-kinesthetic means (visual control). In the tactile-kinesthetic condition, the child's hands were guided by the experimenter along the object's path, which was done behind a screen.

Overall, the results were that reproductions were better in the tactile-kinesthetic condition than in the visual condition. At 4-years, tactile-kinesthetic series scores were much higher than the visual series; but at 5-years, the reverse was true, with the visual series scores being higher than the tactile-kinesthetic series. And at 6-years, performances in the two conditions were equalized.

It was concluded that, for 4-year-olds, tactile-kinesthetic perception produces better motor reproduction than visual perception, either because visual structuring is deficient at this age, or because there is a temporary lack of coordination between vision and gestural motor functions.

<u>The Soviet Perspective</u>

Soviet psychologists have emphasized for a long time the role of sensory activity and motor processes in perception. In the Soviet system (as reviewed by Brožek & Slobin, 1972; Chalfant & Scheffelin, 1969; O'Connor, 1961; Pick, 1964; Rahmani, 1973; Simon, 1957; Zaporozhets, 1958, 1965; Zaporozhets & Elkonin, 1971), perception is said to mirror the world, and the sense organs are used to obtain information by active exploration of objects in the environment. Furthermore, according to this motor "copy" theory, tactual-kinesthetic information is hypothesized to be more basic to young children's perception than visual information. Direct motoric interaction with objects is seen to be a decisive factor in the child's perceptual development, insofar as being able to respond to the various properties and characteristics of objects.

Consistent with this view are the experiments of Zinchenko and Ruzskaya (as reported by Yendovitskaya, Zinchenko, and Ruzskaya, 1971), in which preschool children were asked to become familiar with flat figures of irregular form. The children were assigned to one of four experimental conditions: visual exploration, tactual exploration, visual exploration and tactual exploration, and practical activity (i.e., activity involving the placement of the figures into apertures). The effects of these various conditions of sensory activity were measured by recognition of a previously perceived figure among unfamiliar ones, either by visual means or by tactual means. Results indicate that children perform better through practical manipulation than through a purely sensory form (visual or tactile) of familiarization. Only in the case of older children (5-years) were the results of visual activity (i.e., actions of the eyes) comparable to recognition performance via practical manipulatory activity.

In another study, Jakobson (in Yendovitskaya, et al., 1971) investigated object form recognition in preschool children of 2- to 4-years. Performance was found to be better on the recognition task when the S was presented with an object haptically and asked to visually locate it among other objects in an array, rather than being presented with the object visually and asked to locate it manually. It was concluded on the basis of this particular study, that tactual perception of form develops earlier in the preschool child than visual perception. While tactual perception in the young child can be accomplished without visual assistance, it is contended that tactual activity is a requisite for visual perception of form. It should be noted, however, that tactual perception as it is used here actually pertains to haptic activity.

Summarizing some of these findings, Yendovitskaya, Zinchenko, and Ruzskaya (1971) conclude that activity of the hand performs an essential function in the development of visual perception, "although not as an organ of tactility, but as an organ of activity with objects [p. 47]."

Elsewhere, Zaporozhets (1958) reports ontogenetic changes obtained by Soviet investigators in the orienting activity of children. These experimental findings indicate a transition from tactile-motor to visual orientation as a means of familiarization with new objects. Touch and manipulation decreased from 44% and 26% of the cases studied in children

3- to 4-years, to 21% and 14% of the cases in children 6-7 years; at the same time visual activity increased from 30% to 65% for those same cases studied. Also, it was found that older children still rely quite heavily on sensory-motor forms of familiarization when new objects encountered are of a complex nature--visual examination alone thus being an inadequate means of registering stimulus information.

Other findings described briefly by Zaporozhets (1958) relate to the effects of training. These experiments show that tactile-kinesthetic training produces relatively better results in object familiarization for younger children (3-4 years), whereas training by imitation (i.e., following actions being demonstrated) produces relatively better results for older children (6-7 years).

Other Perspectives

Aside from Piagetian and Russian perspectives, there have been a number of other theorists who claim that sensory-motor functions are basic to early cognitive functioning.

For example, Werner (1948) has postulated that the organism in the course of development progresses from sensory-motor contact with the world, entailing concrete manipulative experiences with objects, to a level of perceptual organization of objects and their properties, to a level of conceptual-symbolic behavior involving manipulation of symbols. The coordination of physical activity or movement and sensory impression is said to be important at the initial level.

Bruner (1964) similarly describes the emergence of representational systems which are necessary for dealing with a complex environment. According to Bruner, there are three of these systems or modes of representation: The first is an action schema enabling the child to understand his world on a concrete basis (enactive); this is followed by the development of an imagery system (iconic), which in turn is followed by a verbal or symbol system (symbolic). More recently, Bruner (1973) has examined the constituent parts of these action schemas.

There have been numerous experimental investigations devoted to a test of the hypothesis, stated in one form or another, that the motor process (e.g., tactual or haptic behavior) is central to the acquisition of knowledge in young children. Appealing as the proposition may be, little empirical support has been offered in its defense. For example, there is presently very little evidence indicating either its centrality or contribution in early childhood perception (e.g., in object form recognition).

In one of the few supportive studies, Denner and Cashdan (1967) tested form recognition in preschool children under three conditions of sensory input: visual only, visual and haptic, and visual and tactual with the object (hexagon, cross, square, or triangle) encased in a clear plastic ball. In the test of recognition, Ss were asked to pick from an array of objects the object which they had previously experienced under one of the three conditions. Recognition performance in the visual-haptic and visual-tactual conditions was superior to the visual condition. The authors concluded that the facilitative effect was due to the amount of concrete activity involved, since performance through visual-haptic and visual-tactual means was equally good. It should be noted by the reader that while the authors refer to the term "tactual" for the third condition, there was actually no tactual activity being employed since the object had been encased.

In two recent Wisconsin R & D experiments, Wolff (1972) investigated the effect of haptic exploration on visual recognition of nonsense forms by children 4- to 7-years. In the first experiment, half of the Ss from each age group were allowed optional haptic activity while visually inspecting the stimulus figures; the remaining half of Ss were not permitted to touch the figures. Subjects in the visual and haptic condition, who voluntarily engaged in haptic activity, took fewer trials in reaching criterion on a repeated exposure-test recognition task, as compared to Ss who were engaged solely in visual inspection. The difference between conditions was also found to decrease with age.

The second experiment was a modification of the first. Four-year-old Ss were assigned to one of three groups: a visual condition, a visual and haptic condition with haptic activity being required, and a touch condition in which the S was required to touch two edges of each figure using the fingers of both hands. On the recognition test, the visual and haptic condition proved to be more facilitating than the visual condition, which in turn was more facilitating than the touch condition.

Negative results have been reported in a host of other studies. Cashdan (1968) studied form discrimination in adult Ss under four conditions of differing sensory input: visual-visual, haptic-haptic, visual-haptic, haptic-visual. Two comparable sets of "nonsense forms" were used as stimuli, one for visual presentation and the other for haptic presentation. Results showed that the visual-visual condition, for which Ss were asked to visually inspect the stimuli and perform the subsequent discrimination task visually, was most conducive to learning.

The authors concluded that haptic form discrimination in adults is inferior to visual form discrimination.

In another study, DeLeon, Raskin, and Gruen (1970) investigated the integrated effect of both visual and tactual cues in preschool children with amphorous shapes. This combination of visual and tactile modes however did not result in any better recognition performance than the use of the visual alone. Balter and Fogarty (1971), as well, have found the quality of the visual modality equivalent to the visual with tactual.

Millar (1971) tested 3- to 4-year-old children on delayed visual and haptic recognition of amphorous shapes under various combinations of sensory input. The visual condition proved to be superior to the haptic in intramodal, crossmodal, and concomitant comparisons. For the 4-year-olds, added visual cures improved haptic recognition, but added haptic cues did not improve visual recognition, suggesting that the visual modality is dominant.

Butter and Zung (1970) reported findings in which visual performance on a recognition task using 3-dimensional forms was equivalent to bimodal performance (visual and haptic). The authors pointed to the need of using younger Ss since, in their study, performance under the bimodal condition did improve gradually with increasing age in children 5- to 8-years. Elsewhere, Pick, Pick, and Klein (1967) found visual-visual matching to be superior to tactual-tactual matching as well as to cross-modal matching. E. Gibson (1969) has argued that the weight of the evidence seems to indicate that the visual modality facilitates touch perception, rather than the other way around.

Psychophysical experiments also have found no supportive evidence that motor-related behavior is a primary information source. Rock and

Harris (1967) examined the assumption in a series of such experiments by presenting contradictory information between vision and touch. In one of their investigations, naive adult Ss were asked to give their impressions about the size of a square solid while viewing the object through a lens which produced a smaller retinal image. In addition to viewing the square through a reducing lens, each S was able to grasp the object with his hand beneath a piece of cloth. The S's impression was assessed by either drawing the size of the square as accurately as possible with the aid of vision and touch, picking out a matching square from a series of squares presented visually, or picking out a matching square from a series which could be grasped. If the hypothesis held true, then the S would realize that he was seeing an object of one size but actually touching an object that was much larger. The results, however, indicated that in each case the Ss were unaware of the conflict existing between vision and touch; the impression made through touch conformed to the illusory visual impression of the square.

Similarly, in an experiment on shape perception, conflicting sensory information was presented between vision and touch. Ss were asked to look at objects through a cylindrical optical device which made things appear narrower. Thus, while the S was looking at an object which appeared to be a rectangle, he was actually touching a square. Again, however, the square felt the way it looked. In the two experiments, touch had no effect on the perceived size or shape of the object.

Discrepancies among the above studies must be reconciled, and so a few observations seem warranted at this time. The first observation concerns the actual role played by the hand in studies demonstrating a facilitation in visual recognition. Abravanel (1972), Weiner and Goodnow (1970) have recently suggested that facilitation may have been due to the "performatory" role played by the hand rather than to a "perceptual" role. Various forms of manipulative activity may help orient objects for visual shape perception. The hand therefore does not function as an information-gathering source in itself, but only helps direct and maintain visual attention.

Secondly, the nature of motor activity is a very important consideration, since failure of many studies to find a facilitating effect can be traced to the kind of manual activity being employed. In unsuccessful studies, explorative movements are usually performed quite freeely over the object for a fixed period of time without any specific exercises being prescribed. If manual activity is to be effective, it must be intense and thoroughgoing so as to force the S to attend to all features of an object (witness the "practical" exercises imposed by Soviet researchers and the curriculum practices of Montesorri, 1964).

Another important factor concerns the visual recognition tasks that have been often used as measures of perceptual learning. In many of the studies, a test series is constructed in such a manner than the target item always appears in its familiarly seen context. For example, a triangle is always presented with its base parallel to the S who is viewing it. To the best of the writer's knowledge, few studies have systematically varied the spatial context or orientation in which a figure appears and thereby required the S to make an identification. Presenting a target item of the test series in an uncommon perspective may help activate certain sensory-motor schemes that reconstruct the item in its more standardized form.

The tasks which were used in the present study based upon those developed by Frayer, Klausmeier, and Nelson (1973) and Klausmeier, Sipple, and Frayer (1973, in press) are specially suited for testing visual recognition when the target item (i.e., a concept example) is put into a different spatial context.

Still another relevant aspect is the age factor. Where previous investigations show motor facilitation, it usually comes about only in the youngest preschool children. Older children (Butter & Zung, 1970) and adults (Cashdan, 1968) presumably depend on visual information and need very little manual activity. But for younger children, "touch" may be an important means of sensitizing oneself to the properties and qualities of unfamiliar objects. In the present study, this relationship is explored further by stratifying Ss in the sample according to age. One-half of the Ss drawn were 3-year-olds while the other one-half were 5-year-olds.

The role of sensory-motor activity has yet to be carefully studied within the context of concept learning and development. Nevertheless, the position taken by Klausmeier, et al. (in press) is that sensory-motor activity is facilitative in the order of concrete, identity and classificatory levels. This is because young children can acquire concepts at these levels but cannot use language well enough either to comprehend events or represent these events internally. Manipulative experiences are held to be more facilitating at the concrete level than at the identity level, and, in turn, to be more facilitating at the identity level than at the classificatory level--because of the reliance on sensory-motor experiences at earlier levels. As the child acquires command of the language and also of successively higher levels of concept attainment, particularly at the classificatory and formal levels, he operates increasingly on a conceptual basis and less so on a perceptual one. When this occurs, language or the verbal (instructional) process becomes dominant and thus supplants sensory-motor functions. Therefore, one would expect motor-related activity to show its greatest influence at the lowest levels of concept attainment, namely at the concrete and identity levels.

Verbal Foundations of Cognitive Behavior

The verbal process has been often overlooked as an important avenue for obtaining knowledge about the world. Piagetian psychologists, for example, have always insisted that cognitive behavior is regulated by sensory-motor functions (either overt or covert), and is not controlled in any direct way by language activity (Furth, 1966, 1971, 1973; Piaget, 1926, 1963, 1967; Sinclair de Zwart, 1966, 1969). In contrast to Piagetians, a long tradition has been established in Soviet psychology, dating back to the early experimental investigations of Vygotsky (1962) and evidenced in the more recent researches of Luria (1957; 1961; Luria & Yudovich, 1968), stressing the importance of speech or language in regulating the child's perceptual acts and attention, as well as in regulating most other higher forms of complex intellectual behavior. In fact, from the Soviet viewpoint sensory-motor activity or direct interaction with the world is later overshadowed by higher mental processes associated with language. Verbal learning gradually replaces sensory-motor learning.

This characterization of ontogenesis finds its origin in Pavlovian terminology. Pavlov (1955), the great Russian physiologist, was the first to explicate a critical distinction between two signaling systems of the organism. The first system of signals, which is common to both man and animal, signals reality through the visual, auditory, and other receptor organs. The second system of signals, species-specific to man, represents a signaling of the first system or the sensory-motor by means of speech or language. Once the basic links (first signaling system) have been established--those that regulate the organism's relationship to its environment through conditioning--new links become formed by using other intermediary links based upon language. "These are the links that are incorporated into man's orienting activity, that abstract and systematize the signals acting on the organism, and inhibit its direct-impulse reactions [Luria, 1961, p. 43]." The formation of verbal links is also what removes man from the direct influence of a given stimulus situation.

In order to gain some appreciation for this view of how verbal functions regulate psychic growth, one must begin by examining the Russian conception of the child's social development (e.g., see Bronfenbrenner, 1972). The child's mental activities are said to be shaped from the very beginning by his social relationships with adults Consequently, language plays a major role in this developmental process since, by its very nature, language is the most predominant form of social intercourse and intercommunication with adults. By naming various surrounding objects and by defining properties and relations of these objects for the child, the parent and teacher shape the child's behavior. This adult influence is important to the whole process of transmission of knowledge and to the formation of concepts in the child. Without adult influence, the child's mental activity would not develop to the same degree of complexity if left to individual experience. The following is descriptive of how this "shaping" process takes place:

> When a mother shows a child something and says "cup," first her pointing and then the name of the object cause an essential modification in the child's perception. By the laws of temporary links, the mother's gesture and the word designating the object become secondary signals causing marked changes in the range of stimuli acting on the child. In isolating the object from its environment, the action of pointing reinforces the stimulus, making it a figure set in a ground. The word designating the object delineates its essestial functional properties and sets it within the category of other objects with similar properties; it serves a complex task of analysis and synthesis for the child, and later settles into a complex system of links acting on him and conditioning his behavior [Luria, 1961, p. 19].

Through communication with adults the child begins to actively name objects in his world and thereby acquires a system of language. Naming assists in the direction of his attention and in the organization of his perceptual acts. As Luria describes the evolutionary change:

> It is obvious to any observer that a child not only watches his mother's index finger but soon begins to use his own to mark given objects off from the environment; not only does he perceive the words he hears, he soon begins actively naming objects. And this is what becomes the main factor in his further mental development. He makes his own use of all the principal relationship-techniques that had earlier proceeded from adults [Luria, 1961, p. 20].

Thus, the word performs a very central function. It indicates not only a corresponding object in the world, a referent, but also serves as a means of abstracting, isolating the signal, and generalizing perceived signals and relating these to certain categories. Furthermore, the word which is linked to the perception of an object helps to isolate that object's essential features (Luria & Yudovich, 1968).

When the child begins to actively use the names he learned through social contact with adults, he becomes capable of modifying the environment which had previously influenced him; he now becomes capable of regulating his own behavior. "Repeating the verbal indication of an object, he places it amongst other directly perceived things and makes it the object of his own complex active attention [Luria & Yudovich, 1968, p. 14]."

Simple experiments reported by Luria (1961) show that it is possible to alter the relative salience of elements in complex visual stimuli by means of language. In one experiment, for example, children as young as 3- and 4-years were presented red and green colored airplanes against gray and yellow backgrounds. This task requires a child to squeeze a bulb with his right hand when a red airplane appears on a yellow ground and to squeeze another bulb with his left hand when a green airplane appears on a gray ground. Typically, the yellow and gray backgrounds serve as the weaker element in the visual compound. However, when the children are given verbal instructions that are meaningful (e.g., "the plane can fly when the sun is shining and the sky is yellow" or "when it's rainy the plane can't fly and has to be stopped"), they react to the supposedly weaker element, the background, rather than to the figures. In other words, the physically weaker component takes on the property of "first signal." These experiments demonstrate that verbal instructions can significantly affect or re-shape one's perception of things, and under optimal conditions can be achieved in very young children.

Another experiment cited by Luria (1961) also illustrates how language can be a basis for elaborating visual configurations. In this particular study, children between 3- and 7-years of age had to press a button with their right hands when a triangle appeared, and another button with their left hands when a square appeared. After reaching criteria by developing the specified reactions to the two figures, the experimenter then presented other control figures consisting of triangles and quadrilaterals of varying sizes and shapes. It was found that all children experienced difficulty in making correct generalized reactions to the perceived figures. Only when the task was thoroughly explained and when the figures were routinely named as they appeared did the children, ages 5 to 7, produce the right reactions.

In another closely related experiment, Luria reports that children even as young as 3- or 4-years can make the correct reactions. However, it can be done only if the child is trained beforehand by taking hold of the objects and manually exploring the contours, by counting angles, and by naming the objects accordingly. The "result was that these actions inhibited impulsive response to immediate impressions, and made it possible for generalized behavior patterns to be formed in children three or four years old [pp. 31-32]." Although details of methodology are rather sketchy, these experiments again demonstrate that the verbal process is an important basis for regulating the young child's perceptual acts.

Continuing with this Soviet line of research, a host of other informative studies can be found which concern the regulative role of verbal instruction in cognitive developmental behavior. Luria and Yudovich (1968) report extensively on an intervention study they undertook with identical twin boys who, like many twins growing up together, were retarded in overall language development. At 5-years of age both children were separated from the "twin situation" and placed in parallel groups in a kindergarten, with one child being given a total of nine months of supplimentary individualized instruction. Lessons for the one child were geared so that he was encouraged to answer questions, repeat phrases, describe pictures, relate stories, and to name objects. The second child served as the "control" twin. Language and general mental development of the twins were checked after three months time and again after ten months.

Separation made it necessary for the twins to develop their language system since non-verbal forms of communication were no longer sufficient. Substantial improvements were detected in the function and grammatical structure of language as early as three months after separation for both the control and the trained twin, although the twin who was specially trained showed better improvement than the control.

More significant, however, were the improvements observed in the children's mental development. Preliminary investigations noted that the twins would engage only in primitive play activity which lacked meaning and a comprehensible content to adults. Rules of a game (e.g., lotto) were inaccessible to the twins, nor could they develop play activity that had been verbally formulated. Constructional activity had also been lacking. The twins were formerly unable to imitate or represent other drawings in their own drawing activity. Furthermore, they had not developed classificatory skills at their age; they could not group common objects but instead would arrange them together, one after another, without an operational scheme.

As a result of intervention, marked changes had taken place. Play activity became more objective and meaningful. The twins were now able to understand the rules of play as well as to carry out projects which were verbally formulated. Drawings became more goal-directed, differentiated, and objective. Classificatory skills also began showing notable improvement.

Although both twins benefited from intervention, inter-pair differences existed between them. The child who was given supplementary lessons performed better in visual analysis of drawings having anomalies, showed more elaboration of detail while relating a story, and had a more highly developed classificatory scheme. On the latter point, the trained child could classify with the aid of language (e.g., by placing a toy sailor together with a toy boat), while the control child could only classify on a perceptual basis (i.e., according to color and form). Again, the results of Soviet experiments indicate that language can substantially alter perceptual-cognitive behavior in young children.

The verbal process is also seen to be a powerful guiding factor in the formation of concepts. According to Vygotsky (1962), the word performs an indispensable function in two areas of a child's concept development: (1) Thinking in "complexes"--grouping diverse objects under a common label, and (2) Formation of "potential concepts"--abstracting common attributes among objects.

Russian educational psychologists have studied rather extensively the regulative role of language in children's concept learning (see Simon & Simon, 1963). Zankov (1963), for example, carried out a series of observational and experimental investigations to study mastery of knowledge in primary school children through verbal means. The specific purpose was to ascertain the most effective methods of combining the verbal and visual when teachers present new materials to school children, and to assess the effectiveness of these pedagogical methods. Two forms of combining the verbal and visual were of particular concern: (1) The use of the teacher's words in directing children's attention toward physical properties of a given object, whereby knowledge is acquired through the visual process and the verbal acts solely as a guide; (2) The use of the teacher's words to impart knowledge of the physical properties of an object, with the visual process serving only as a reinforcer to concretize the verbal exposition. The effectiveness of these two approaches was examined in a classroom setting with the administration of elementary science lessons. It was found that the first approach, visual learning with verbal direction, showed greater efficacy as measured by the total number of correct answers given to questions after the lessons.

Further experimental investigations were conducted in order to shed more light on the above findings. Primary school children were presented a task of differentiating between physically similar objects after being given preliminary verbal instruction either in the form of a general indication or in the form of a reinforcement. Because of a lack of clarity and some ambiguity in the data that are reported, which may have been a consequence of translation, results of this series of investigations are not summarized here. However, it is concluded on the basis of these investigations that in itself the word is not as "omnipotent" as sometimes believed, that slight variations in the character of the teacher's verbal instructions can drastically affect school children's mastery of knowledge. The word does not always produce the desired generalization of an object's properties for children. Thus, it "is necessary to use those forms of combination of the verbal and visual which show higher effectiveness in relation to the given school work and to use them in specific conditions [Zankov, 1963, p. 256]."

To summarize, a number of studies have been reviewed above which indicate that the word is often a powerful agent for regulating children's cognitive acts. Although Soviet research is not the only line for investigating the nature and function of the verbal process, it, nevertheless, represents the most concentrated research effort in this area of scientific inquiry. The implications in the present study are readily apparent. First, in view of results of Luria's (1961) experiments, verbal instructions can indeed influence a young child's perception of complex visual stimuli, even as young as 3- to 4-years of age. This has relevance for the concrete and identity tasks used in the present study, since these two tasks require young children (3- and 5-year olds) to visually recognize geometric forms on the basis of distinguishing features. Consequently, the treatment conditions which emphasize verbal instruction are expected to facilitate children's performance on these two tasks.

Secondly, results of the intervention study reported by Luria and Yudovich (1968) would also indicate that verbal instructions can be a facilitating influence on classificatory behavior. As has already been noted, supplementary verbal instructions for the trained twin enabled him to classify objects at a much higher conceptual level than the control twin who did not have the benefit of these instructions. Therefore, the treatment conditions which emphasize verbal instruction are also expected to facilitate performance on the classificatory task used in the present study, at least insofar as the 5-year-old subjects are concerned.

Thirdly, the combination of the verbal and visual as reported in Zankov's (1963) investigations has an important bearing on the present study. In general, Zankov observes that verbal instructions show their greatest influence on children's mastery of knowledge when they are used to aid or direct visual activity, rather than when they are used in verbal exposition (i.e, in defining concrete objects). As a result, the verbal treatment conditions of the present study have been primarily designed for guiding or supplementing the subject's visual activity. That is, verbal instructions are intended to direct subject's attention to the features and to the defining characteristics of concept examples and non-examples.

Klausmeier, et al. (in press) view language as an increasingly powerful variable at successively higher levels of concept attainment. According to the CLD model, as the child achieves successively higher levels of a concept, particularly at the classificatory and formal levels, he operates increasingly on a conceptual basis and also uses words to represent his concepts. Inasmuch as the child comprehends the meaning of words, the effects of verbal orienting instruction are predicted to increase. According to Klausmeier (personal communication) the CLD model implies that the higher the level of concept attainment the lesser are the relative effects of sensory experiencing (i.e., sensory-motor and visual behavior), and the greater are the relative effects of verbal behaviors, that is naming and generalizing that different instances belong to the same class based on abstracted properties of these instances. Verbal instructions which teach the names of concepts and their attributes should facilitate conceptualization.

Summary. A survey of the literature above has shown that both sensory-motor and verbal functions represent an important aspect of cognitive behavior. On the basis of this background literature, it may be possible to predict the outcomes of sensory-motor training and verbal orienting instruction on the attainment of concepts at successively higher levels. Concept learning and development constitute an important aspect of cognition, and, thus far, have received very little attention in terms of the internal conditions which might facilitate the acquisition of concepts.

From the perspectives of Soviet cognitive psychologists and the CLD model, one might expect sensory-motor behavior to be more instrumental in the process of attaining concepts at the lower levels (e.g., concrete and identity) and verbal behavior to be more instrumental at the higher levels (e.g., classificatory and formal). A child who achieves successively higher levels of the same concept will depend increasingly on the mechanisms of language for obtaining pertinent information about the defining attributes of objects, events, and processes. From both the Soviet and CLD viewpoints, language is more closely associated with complex forms of conceptual activity than sensory-motor behavior.

It is not, however, so easy to make predictions of the outcomes of sensory-motor training and verbal orienting instruction on concept attainment from the standpoint of Piagetian theory. Piaget's theory seems to have tapped another aspect of the cognitive spectrum, one which is quite different, for example, from the CLD model. While Piaget has studied concepts in his own way rather extensively and has even included the term (i.e., "concept") in many of his published works, he has been essentially concerned with logico-mathematical strategies and achievements, not in the acquisition and organization of knowledge or what is sometimes referred to as "physical" or "figurative knowledge." In spite of the difference in orientation, Piaget has made his views known about the role of sensory-motor functions and verbal functions in relationship to intellectual development. Sensory-motor activity is said to be the basis of intellectual development while verbal activity is claimed to be indirect and less important. Even when Piaget or interpreters of Piagetian theory (e.g., Furth, 1969; Ginsburg & Opper, 1969) have occasionally admitted that verbal behavior might assist intellectual development, it has never been spelled out quite clearly how this might happen.

In view of the literature and varying theoretical viewpoints that have been presented, it was predicted in the present experiment that verbal orienting instruction would be a more powerful variable in attaining successive levels of the same concept, particularly when combined with sensory-motor or manual activity. In particular, Conditions 4 and 2 were predicted to have a relatively greater effect than Condition 3. Furthermore, visual activity (Condition 1) and unrelated play behavior (Condition 5) were predicted to be least facilitating of all conditions. Five-year-old Ss were, of course, predicted to do better than 3-year-old Ss in each of the conditions. Three-year-olds were also predicted to do better when engaging in a form of sensory-motor or manual activity, while 5-year-olds were predicted to do better when given verbal orienting instruction.

Chapter III

EXPERIMENTAL METHOD

The purpose of this experiment was to ascertain the relative effects of certain forms and combinations of sensory-motor activity and verbal orienting instruction on early concept formation. The concept identified in the present study was that of equilateral triangle which can be defined on the basis of perceptible attributes (i.e., three equal sides and angles). The specific questions raised in this experiment were the following:

1. What are the effects of various combinations of visual inspection, sensory-motor training, and verbal orienting instruction on children's concept attainment at each of three levels--concrete, identity, and classificatory?
2. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to age?
3. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to sex?

Subjects

One hundred children of ages 3- and 5-years were recruited for this experiment--50 Ss at each age level. The 3-year-olds were drawn from day-care centers of Child Development Incorporated in the vicinity of Madison, Wisconsin. Five-year-olds were taken from kindergarten classrooms of Kegonsa Elementary School in Stoughton, Wisconsin. The mean age of the 3-year-old Ss was 3.6 years; mean age of the 5-year-olds was 5.8 years.

Subjects were first stratified during the selection procedure according to age and sex and then randomly assigned to one of the five treatment groups. Consequently, there were five boys and five girls trained and assessed in each age x treatment condition.

Experimental Materials

Training Materials

The stimuli used to train Ss in treatment conditions I-IV were 36 wooden blocks. These blocks were used in previous Wisconsin R & D studies by Frayer, Klausmeier, and Nelson (1973) and Klausmeier, Sipple, and Frayer (1973, in press). The blocks varied along four dimensions: shape of surface area (equilateral triangle, right isosceles triangle, or square), color (blue, red, or yellow), size (large or small), and thickness (thick or thin). It should be noted that the blocks themselves did not conform to equilateral triangles, right triangles, or squares--only the edges of the surface areas had such shapes. Specifications for the geometric blocks are given in Table 1. No indication of the block number was made on the block itself; the designation of numbers was made only for the convenience of the E.

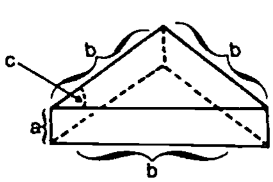
Stimuli which were used in the control condition (Condition V) consisted of crayons and coloring pictures of animals.

Table 1

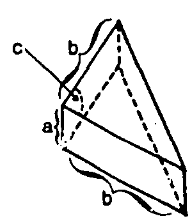
Specifications for Stimulus Blocks Used in the Treatment Conditions

Block Number	Shape of Surface Area	Color	Thickness a (in millimeters)	Length of Side b (in millimeters)	Angle c (in degrees)
1	Equilateral Triangle	Blue	20	100	60°
2	Equilateral Triangle	Blue	10	100	60°
3	Equilateral Triangle	Blue	20	66.7	60°
4	Equilateral Triangle	Blue	10	66.7	60°
5	Equilateral Triangle	Red	20	100	60°
6	Equilateral Triangle	Red	10	100	60°
7	Equilateral Triangle	Red	20	66.7	60°
8	Equilateral Triangle	Red	10	66.7	60°
9	Equilateral Triangle	Yellow	20	100	60°
10	Equilateral Triangle	Yellow	10	100	60°
11	Equilateral Triangle	Yellow	20	66.7	60°
12	Equilateral Triangle	Yellow	10	66.7	60°
13	Right Triangle	Blue	20	87.87	90°
14	Right Triangle	Blue	10	87.87	90°
15	Right Triangle	Blue	20	58.58	90°
16	Right Triangle	Blue	10	58.58	90°
17	Right Triangle	Red	20	87.87	90°
18	Right Triangle	Red	10	87.87	90°
19	Right Triangle	Red	20	58.58	90°
20	Right Triangle	Red	10	58.58	90°
21	Right Triangle	Yellow	20	87.87	90°
22	Right Triangle	Yellow	10	87.87	90°
23	Right Triangle	Yellow	20	58.58	90°
24	Right Triangle	Yellow	10	58.58	90°
25	Square	Blue	20	75	90°
26	Square	Blue	10	75	90°
27	Square	Blue	20	50	90°
28	Square	Blue	10	50	90°
29	Square	Red	20	75	90°
30	Square	Red	10	75	90°
31	Square	Red	20	50	90°
32	Square	Red	10	50	90°
33	Square	Yellow	20	75	90°
34	Square	Yellow	10	75	90°
35	Square	Yellow	20	50	90°
36	Square	Yellow	10	50	90°

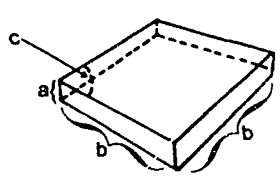
Equilateral Triangle



Right Triangle



Square



Assessment Materials

The CLD tasks (Frayer, Klausmeier, & Nelson, 1973; Klausmeier, Sipple, & Frayer, 1973, in press) were used to measure transfer of training at the concrete, identity, and classificatory levels. Two types of stimuli were included in the assessment battery: (1) geometric blocks which were used during the training phase to measure near transfer (see Table 1), and (2) two-dimensional drawings were used in a parallel test to measure far transfer. The second type of materials represented geometric forms similar to the blocks. These materials are presented in Appendix A.

In addition to the training materials, a 24" x 16" masonite panel was used in concealing blocks for the concrete and identity tasks. The panel stood in a vertical position on a wooden base and could be operated manually.

Procedure

Training

The author administered the training on an individual basis. Each child was taken from his classroom to a private room where he was seated at a table of an appropriate height. The E sat directly across the table from the S. Since each S had already been acquainted with the E through prior classroom contact, only a brief introduction was necessary before getting underway.

The amount of time allotted in attending to the stimuli was equalized for all conditions. Table 2 illustrates how the training time was distributed for the various conditions over a total of 16 minutes. When a S began to show signs of fatigue or when his eyes were not fixating on the stimuli, the session was stopped at the end of that particular time segment. As many as three to four sessions were sometimes required in order to complete 16 full minutes of training for each S.

Treatment I (visual inspection)

"I got some blocks here that I would like you to see. I want you to look at each block very carefully, taking as much time as you need. Be sure to look at all the blocks and keep your hands in your lap. O.K?"

"We will begin by looking at each of these blocks." (E proceeded by presenting each of the twelve "square" geometric forms for visual examination. Blocks #25-36 were placed upon the table in S's view in a randomly given order. E then removed the blocks from S's view taking away one block at a time.)

(4 minutes allowed for visual inspection of the "square" geometric forms)

"Now we will look at some different blocks." (E presented each of the twelve "equilateral triangle" forms for visual examination. Blocks #1-12 were placed upon the table in S's view in a randomly given order. E then removed the blocks from S's view taking away one block at a time.)

(4 minutes allowed for visual inspection of the "equilateral triangle" geometric forms)

"This time we are going to look at these blocks." (E presented each of the twelve "right isosceles triangle" forms for visual examination. Blocks #13-24 were placed upon the table in S's view in a randomly given order. E then removed the blocks from S's view taking away one block at a time.)

Table 2

Distribution of Training Time by Treatment Condition

	1 4 Minutes	2 4 Minutes	3 4 Minutes	4 4 Minutes
TREATMENT 1	Visual Inspection "squares"	Repeat "equilaterals"	Repeat "rights"	Repeat "all blocks"
TREATMENT 2	Visual Inspection "all blocks"	Verbal Instruction "squares"	Repeat "equilaterals"	Repeat "rights"
TREATMENT 3	Visual Inspection "all blocks"	Free Haptic Activity "all blocks" → (6 minutes)		Tactile-Kinesthetic Training #1,2,3,4,13,14,15,16,25,26,27, & 28 → (6 minutes)
TREATMENT 4	Visual Inspection "all blocks"	Free Haptic "all blocks"	Tactile-Kinesthetic #1,2,3,4,13,14,15, 16,25,26,27, & 28	Verbal Instruction "all blocks"
TREATMENT 5	Unrelated Play Activity → (16 minutes)			

(4 minutes allowed for visual inspection of the "right isosceles triangle" geometric forms)

"Now let's take a look at all of the blocks that I have shown you." (E presented all of the geometric forms for visual examination. Blocks #1-36 were placed upon the table in S's view in a randomly given order. E removed blocks.)

(4 minutes allowed for visual inspection of all the geometric forms)

Treatment II (visual inspection + verbal orienting instruction)

"I got some blocks here that I would like you to see. I'm going to tell you some important things about all these blocks, and I want you to listen very carefully keeping your hands in your lap. O.K?"

"First, I want you to look at all of the blocks that are here on the table." (E presented all of the geometric forms, one at a time, for visual examination. Blocks #1-36 were placed upon the table in S's view in a randomly given order. E removed blocks.)

(4 minutes allowed for visual inspection of all the geometric forms)

"Now I will tell you some things about the blocks you were looking at. We will begin with these blocks." (E placed the twelve "square" geometric forms #25-36 on the table.) "What are these blocks called?" (E awaited S's response.) "These are squares and they have four equal sides. Each of these blocks has the same sides." (E pointed to the four sides of block #25 and to the four sides of block #32.) "Look at the way they are different. How many colors can you find?" (E awaited S's response.) "There are three different colors: blue, red, and yellow." (E sorted the "square" forms into three color groups of blue, red, and yellow.) "See the different colors?" (E returned blocks to one main group.) "How many different sizes do you see?" (E awaited S's response.) "There are two sizes: some of these blocks are big and some are little." (E then sorted the blocks into two groups on the basis of size.) "See the different sizes?" (E returned blocks to one main group.) "Now what is another way in which some of these blocks look different?" (E awaited S's response.) "Some of these blocks are fat and some are skinny. Can you see which are the fat blocks and which are the skinny ones?" (E awaited S's response. E then sorted the blocks into two groups on the basis of thickness.) "See how some blocks are fat and some are skinny?" (E returned blocks to one main group.)

(4 minutes allowed for verbal orienting instruction of the "square" geometric forms)

"This time I will tell you about these blocks." (E placed the twelve "equilateral triangle" geometric forms #1-12 on the table.) "What are these blocks called?" (E awaited S's response.) "These are triangles with three equal sides. Each of these blocks has the same sides." (E pointed to the three sides of block #1 and to the three sides of block #8.) "Look at the way these blocks are different. How many colors can you find?" (E awaited S's response.) "There are three different colors: blue, red, and yellow." (E sorted the "equilateral triangle" forms into three color groups of blue, red, and yellow.) "See the different colors?" (E returned blocks to one main group.) "How many different sizes do you see?" (E awaited S's response.) "There are two sizes: some of these blocks are big and some are little." (E then sorted the blocks into two groups on the basis of size.) "See the different sizes?" (E returned blocks to one main group.) "Now what is another way in which some of these blocks look different?" (E awaited S's response.) "Some of these blocks are fat and some are skinny. Can you see which are the fat blocks and which are the skinny ones?" (E awaited S's response. E then sorted the blocks into two groups on the basis of thickness.) "See how some blocks are fat and some are skinny?" (E returned blocks to one main group.)

(4 minutes allowed for verbal orienting instruction of the "equilateral triangle" geometric forms)

"Lastly, I want to tell you about the other triangles." (E placed the twelve "right isosceles triangle" geometric forms #13-24 on the table.) "These are different from the other triangles I showed you before; they only have two equal sides. Each of these blocks has only two sides the same." (E pointed to the two equal sides of block #13 and to the longest side. E pointed to the sides of block #20 as another example.) "Look at the way these blocks are different. How many colors can you find?" (E awaited S's response.) "There are three different colors: blue, red, and yellow." (E sorted the "right triangle" forms into three color groups of blue, red, and yellow.) "See the different colors?" (E returned blocks to one main group.) "How many different sizes do you see?" (E awaited S's response.) "There are two sizes: some of these blocks are big and some are little." (E then sorted the blocks into two groups on the basis of size.) "See the different sizes?" (E returned blocks to one main group.) "Now what is another way in which some of these blocks look different?" (E awaited S's response.) "Some of these blocks are fat and some are skinny. Can you see which are the fat blocks and which are the skinny ones?" (E awaited S's response. E then sorted the blocks into two groups on the basis of thickness.) "See how some blocks are fat and some are skinny?" (E returned blocks to one main group.)

(4 minutes allowed for verbal orienting instruction of the "right isosceles triangle" geometric forms)

Treatment III (visual inspection + free haptic activity + tactile-kinesthetic training)

"I got some blocks here that I would like you to see. We are going to play some games with them. O.K?"

"First, I want you to look at all of the blocks that are here on the table." (E presented all of the geometric forms, one at a time, for visual examination. Blocks #1-36 were placed upon the table in S's view in a randomly given order. E removed blocks.)

(4 minutes allowed for visual inspection of all the geometric forms)

"Now you can pick up the blocks and play with them. Pick up any block you want to play with. Be sure to play with all the blocks so that you get to know them better."

(6 minutes allowed for free haptic activity with blocks)

"Now we are going to play a game by tracing the blocks with our finger. Show me your pointing finger. We will begin with the blocks here (#1-4). Let's trace our finger around each of the blocks." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) and pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block beginning with the first one.) "Next, we will use three fingers (right thumb, right index finger, right middle finger) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.)

"This time we will be tracing these blocks (#13-16) with our fingers. Let's trace our finger around each of the blocks." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) to pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block.) "Next, we will use three fingers (right thumb, right index finger, right middle finger) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.)

"And now we will trace our finger around these blocks (#25-28)." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) to pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block.) "Next, we will use four fingers (right thumb and first three fingers) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.)

"Now let's try these blocks (blocks #1, 13, & 25)." (E proceeded first by tracing S's index finger around each of the blocks, then used thumb and first two fingers, or thumb and first three fingers in the case of squares, pressed against the sides simultaneously.) (Sequence repeated with blocks #2, 14, & 26; #3, 15, & 27; and #4, 16, & 28.) (6 minutes allowed for tactile-kinesthetic training with blocks)

Treatment IV (visual inspection + free haptic activity + tactile-kinesthetic training + verbal orienting instruction)

"I got some blocks here that I would like you to see. We are going to play some games with these blocks and I will tell you things about them."

"First, I want you to look at all of the blocks that are here on the table." (E presented all the geometric forms, one at a time, for visual examination. Blocks #1-36 were placed upon the table in S's view in a randomly given order. E removed blocks.)

(4 minutes allowed for visual inspection of all the geometric forms)

"Now you can pick up the blocks and play with them. Pick up any blocks you want to play with. Be sure to play with all the blocks so that you get to know them better."

(4 minutes allowed for free haptic activity with blocks)

"Now we are going to play a game by tracing the blocks with our finger. Show me your pointing finger. We will begin with the blocks here (#1-4). Let's trace our fingers around each of the blocks." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) and pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block beginning with the first one.) "Next, we will use three fingers (right thumb, right index finger, right middle finger) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.)

"This time we will be tracing these blocks (#13-16) with our finger. Let's trace our finger around each of the blocks." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) to pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block.) "Next, we will use three fingers (right thumb, right index finger, right middle finger) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.)

"And now we will trace our finger around these blocks (#25-28)." (E guided S's index finger around the sides of each block pressing S's finger against the angles as they are passed over.) "This time we will use two fingers (right thumb and right index finger) to pinch each block." (E then pressed S's thumb and index finger together against the body thickness of each block.) "Next, we will use four fingers (right thumb and first three fingers) to pick up each block." (E then pressed S's thumb and fingers simultaneously against the sides of the blocks alternating in the sequence with large and small blocks.) (4 minutes allowed for tactile-kinesthetic training with blocks)

"Now I'm going to tell you some things about the blocks we just played with. Do you see all the different kinds of blocks? How many colors can you find?" (E awaited S's response.) "There are three different colors: blue, red, and yellow." (E sorted blocks into the three color groups of blue, red, and yellow.) "See the different colors?" (E returned blocks to one main group.) "How many different shapes do you see here?" (E awaited S's response.) "There are three different shapes: some are triangles with three equal sides (E pointed to the 3 sides of block #1); some are triangles with only two equal sides (E pointed to the 2 equal sides of block #13); and some are squares with four equal sides (E pointed to the 4 equal sides of block #25)." (E then sorted the blocks into three groups on the basis of shape.) "See the different shapes?" (E returned blocks to one main group.)

"How many different sizes do you see?" (E awaited S's response.) "There are two different sizes: some of the blocks are big and some of the blocks are little." (E then sorted the blocks into two groups on the basis of size.) "See the different sizes?" (E returned blocks to one main group.)

"Now what is another way in which some of these blocks look different?" (E awaited S's response.) "Some of the blocks are fat and some of the blocks are skinny." (E sorted the blocks into two groups on the basis of thickness.) "See how some blocks are fat and some blocks are skinny?" (E returned blocks to one main group.)
(4 minutes allowed for verbal orienting instruction of blocks)

Treatment V (control)

"I got a picture here I would like you to color for me. Do you think you can color this picture?"
(16 minutes allowed for play activity)

Assessment

Each S was tested for level of attainment of the concept of equilateral triangle after training had been completed. The dependent or transfer measures were taken a day following the completion of training in order to minimize fatigue and to maintain each S's attention. Despite this one day interval, Ellis (1965) notes that training still remains roughly constant with varying time intervals between training and the administration of transfer tasks.

An independent E took all the required dependent measures. This person had no knowledge of the training which Ss received prior to testing. Two sets of tasks were used to measure transfer of training at the concrete, identity, and classificatory levels. Concept attainment was assessed with the use of the training blocks (near transfer) and with the use of two-dimensional drawings (far transfer). The present study is characterized as a treatment-posttest situation. Training involved stimulus predifferentiation (Ellis, 1965; Klausmeier & Davis, 1969) whereby Ss were given different types of experience with the stimuli prior to the test of concept attainment.

The order of presentation was randomized for each S, so that some Ss were assessed first with the geometric blocks followed by the two-dimensional geometric drawings, while other Ss were assessed in the reverse order. Furthermore, the presentation order within each concept task bettery (concrete, identity, and classificatory) had been randomize for each S. A practice trial was given at the beginning of either the concrete or identity task, depending on which occurred first in the assessment battery. The purpose of the practice trial was to clarify the E's instructions.

Equilateral Triangle Tasks (Geometric Blocks)

Concrete Task. In this task, E presented a target block for 5 seconds. While S viewed the block, E said, "Here is a block I would like you to look at." (E pointed to the target block.) "Look at it very carefully and remember what it looks like. Now I'm going to hide the block and ask you to point to it when you see it again."

Experimenter then hid the target block behind a panel. While the panel was in position, E placed the target block among nonexamples. The target block was left in the same orientation with respect to S as when it was initially displayed. The panel was in position for 15 seconds. The E then removed the panel and said, "Now point to the block I showed you before."

The task consisted of four trials utilizing four different blocks as target stimuli. On eact trial, the nonexamples differed in one characteristic from the target block. The blocks used for each trial are specified below:

a. Practice Trial

   Target #32. Nonexamples #10, 19.

1. Target #2. Nonexamples #1, 4, 6, 10, 14, 26.
2. Target #12. Nonexamples #4, 8, 10, 11, 24, 36.
3. Target #5. Nonexamples #1, 6, 7, 9, 17, 29.
4. Target #3. Nonexamples #1, 4, 7, 11, 15, 27.

In the second display, the target and nonexamples were placed in two rows, approximately the same distance from the S as the target in the initial display. The placement of the target in relation to the nonexamples was systematically alternated (center, right, left, etc.). On trials 1-4, the nonexamples intuitively most similar to the target (triangles of the same color) were dispersed throughout the display. All blocks were "regularly" oriented. The initial and second displays for each of the four trials are shown in Figure 6.

An intentional interval of approximately 30 seconds was introduced between each trial. During this interval, E engaged the child in friendly conversation. The purpose of the interval was to minimize interference between trials due to memory of previous target blocks. The delay and conversation were intended to separate the trials in the child's mind.

Identity Task. In this task, E presented a target block for 5 seconds. While S looked at the block, E said, "Here is a block I would like you to look at." (E pointed to the target block.) "Look at it very carefully and remember what it looks like. Now I'm going to hide the block and ask you to point to it when you see it again."

Experimenter then hid the target block behind a panel. While the panel was in position, E placed the target block among nonexamples. The target block was placed in a different orientation with respect to S than when it was initially displayed. The panel was in position for 15 seconds. The E then removed the panel and said, "Now point to the block I showed you before."

The task consisted of four trials which utilized the same stimuli as in the concrete level task. Again, as in the concrete task, each nonexample differed in one characteristic from the target block for each trial. The blocks used for each trial and the orientation of the target block for the initial and test displays are specified below:

1. Target #2. Nonexamples #1, 4, 6, 10, 14, 26.

   (Display 1: Target block is 6" from the edge of the table nearest S, placed such that its equilateral area faces up from

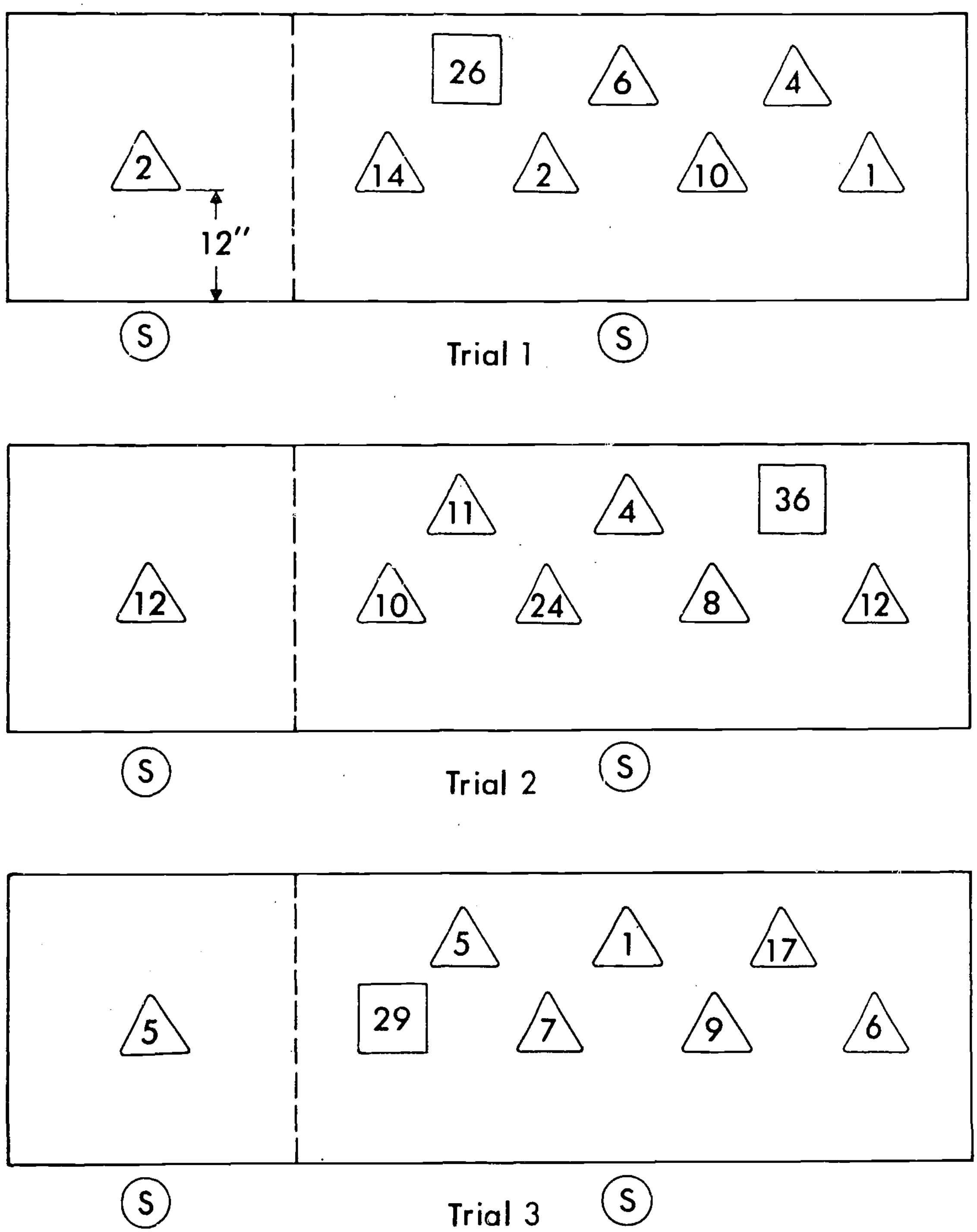
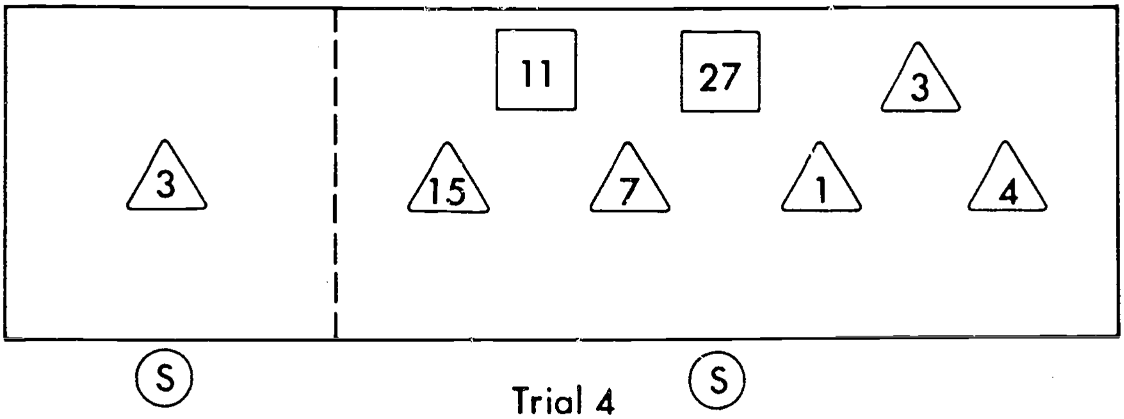


Figure 6. Initial and test displays for each trial of the equilateral triangle concrete task.



Trial 4

CONCRETE

KEY

block is lying on table with base toward subject

subject

Figure 6 (cont.). Initial and test displays for each trial of the equilateral triangle concrete task.

the table. Display 2: Target block is 18" from the edge of the table nearest S, again placed such that its equilateral area faces up from the table. Nonexample 4 is 6" from the edge of the table nearest S.)

2. Target #12. Nonexamples #4, 8, 10, 11, 24, 36.
   (Display 1: Target block is placed such that its equilateral area faces upward from the table. Display 2: Target block is again placed such that its equilateral area faces upward from the table, but one of the points faces directly toward S.)
3. Target #5. Nonexamples #1, 6, 7, 9, 17, 29.
   (Display 1: Target block is placed such that its equilateral area faces upward from the table. Display 2: Target block is placed such that its equilateral area faces directly toward S, with the block resting on a base of the triangle.
4. Target #3. Nonexamples #1, 4, 7, 11, 15, 27.
   (Display 1: Target block is placed such that its equilateral area faces upward from the table. Display 2: Target block is placed such that a side of the triangle faces directly toward S, with the block resting on a base of the triangle.

In the second displays, three blocks were placed upright: one with its flat area toward S, one with its side toward S, one at an angle with regard to S. One upright block was a triangle of the same color as the target, another upright block either a square or a triangle of a different color than the target. Of the blocks which were flat on the table, some had "regular" orientation, others had "skewed" orientation. The initial and second displays for each of the four trials are shown in Figure 7.

An intentional interval of approximately 30 seconds was again introduced between each trial. During this interval, E engaged the child in friendly conversation. The purpose of the interval was to minimize interference between trials due to memory of previous target blocks. The delay and conversation were intended to separate the trials in the child's mind.

Classificatory Task. This task consisted of four sorts. For each sort, S was presented with a target block, then asked to pick out all the other blocks from an array having the same shape as the target.

Experimenter presented a target block for 5 seconds. While S viewed the block, E said, "Here is a block I would like you to look at. Look at it very carefully and remember what it looks like. Now I'm going to hide the block." The E removed the block from the table. On the left-hand side of the S was an array of blocks which had been placed there at the beginning of the sort. "Now pick out all the blocks that have the same shape as the one I showed you before." On Sort 4, E said, "Now pick out all the blocks that have the same shape and color as the one I showed you before."

The blocks used for each sort are specified below:

1. Show #2

   Array #1, 4, 15, 18, 26, 31.

2. Show #12

   Array #3, 8, 10, 15, 20, 21, 23, 35, 36.

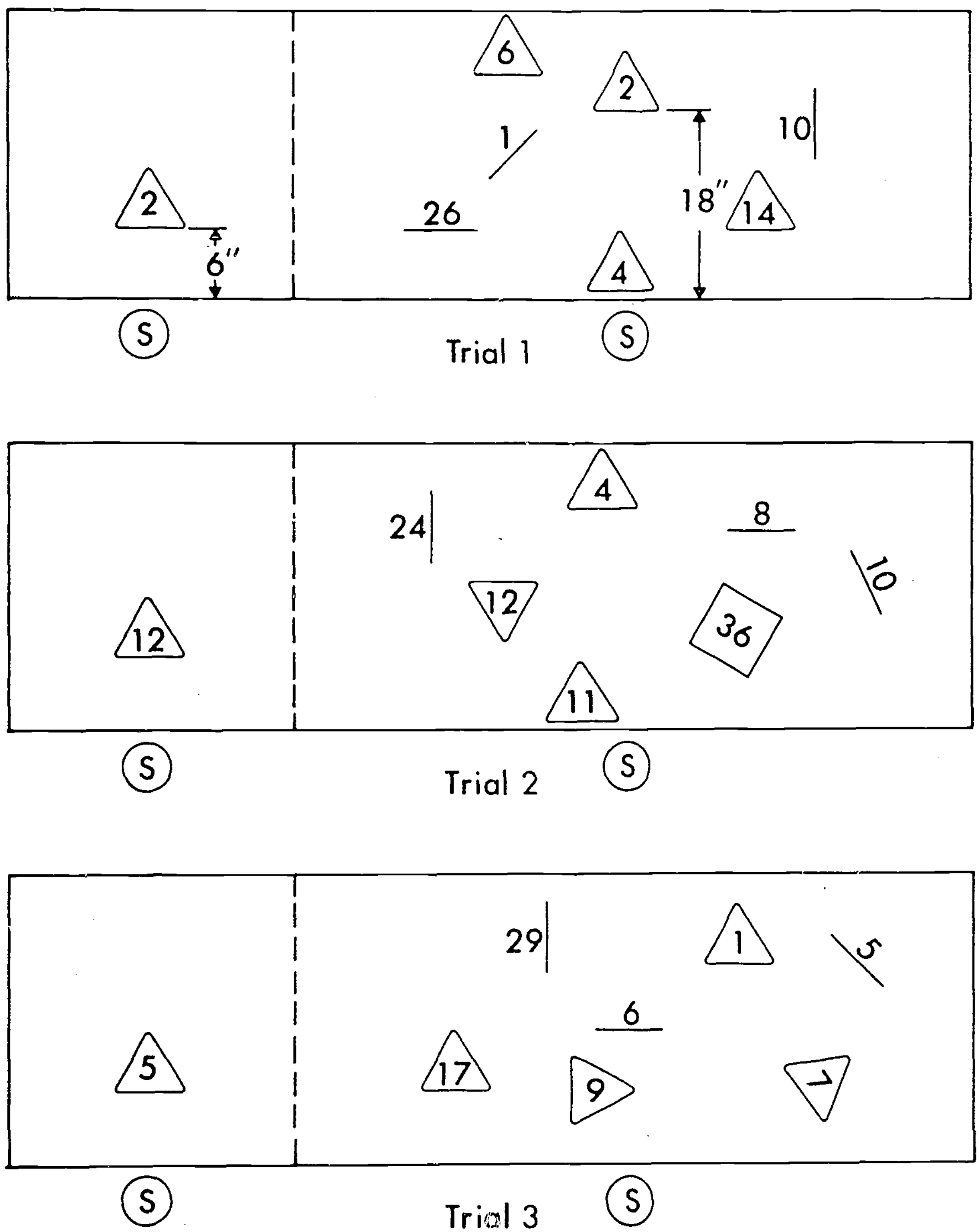
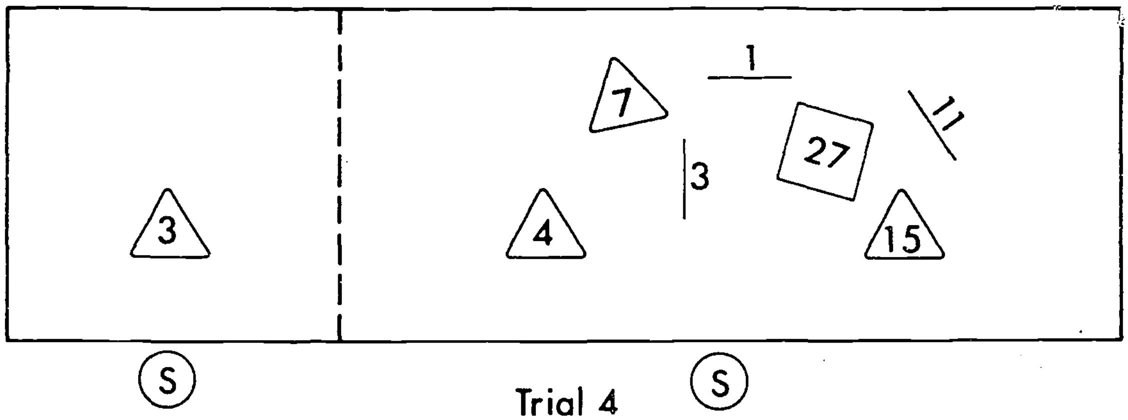


Figure 7. Initial and test displays for each trial of the equilateral triangle identity task.



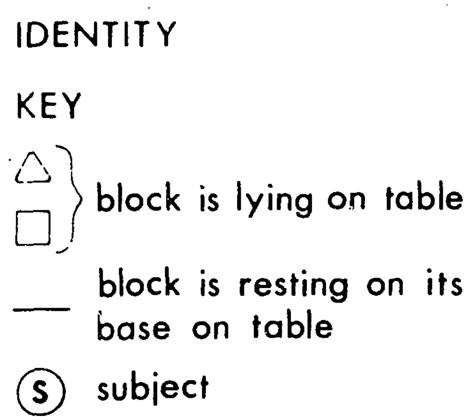


Figure 7 (cont.). Initial and test displays for each trial of the equilateral triangle identity task.

3. **Show** #5

Array #3, 4, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22.

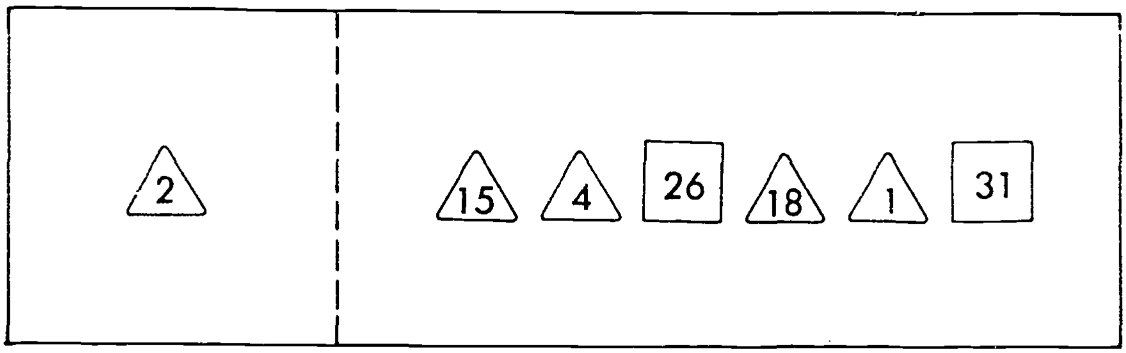
4. Show #3

Array #1, 2, 4, 7, 8, 11, 12, 13, 14, 15, 16.

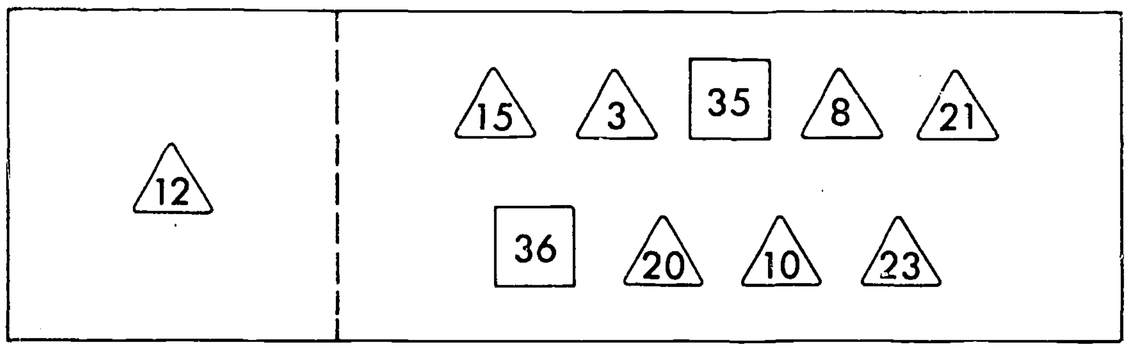
The four sorts were ordered in terms of increasing difficulty. For Sort 1, the array consisted of six blocks of which two were of the same shape as the target. For Sort 2, there were nine blocks, three of these were of the same shape as the target. In Sort 3, the array included twelve blocks and four had to be selected. Finally, in Sort 4, the S had to pick out from the array those blocks that were like the target in both shape and color. The target blocks used in the four sorts were the same targets as in the concrete and identity level tasks. This provided some sense of continuity between tasks for assessing level of concept attainment. Figure 8 illustrates the arrangement of blocks for each sort.

Equilateral Triangle Tasks (Two-Dimensional Geometric Forms)

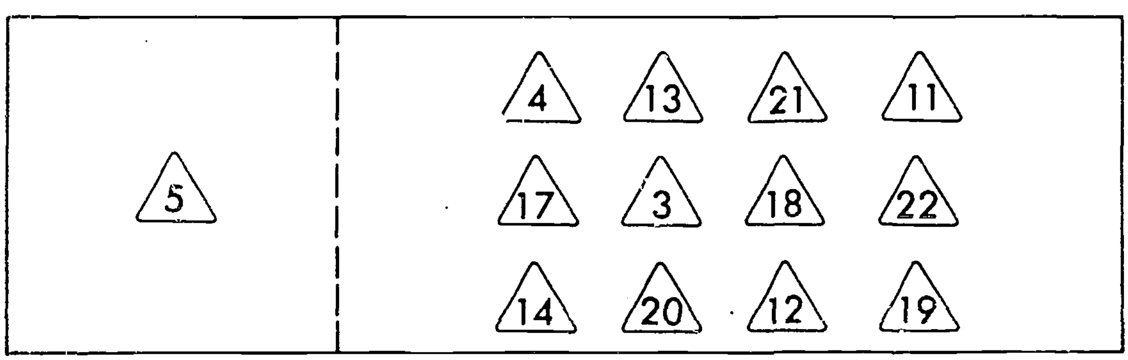
Concrete Task. An assessment task developed by Klausmeier, Ingison, Sipple, and Katzenmeyer (1973) was used for measuring attainment of the concept of equilateral triangle at the concrete level. The test items consisted of two-dimensional representations of geometric forms. The items were administered to each S in polystyrene loose-leaf booklets. After the S was given the practice trial, E presented a target item as the initial display for 5 seconds. This was a line drawn equilateral triangle.



Sort 1

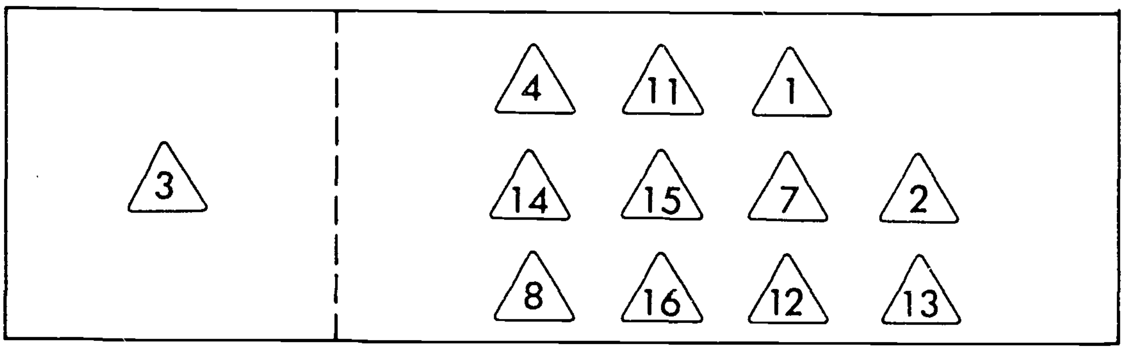


Sort 2



Sort 3

Figure 8. Initial and test displays for each sort of the equilateral triangle classificatory task.



Sort 4

CLASSIFICATORY

KEY

△ □ } blocks are lying on table in rows with bases toward subject

Figure 8 (cont.). Initial and test displays for each sort of the equilateral triangle classificatory task.

While S viewed the item, E said, "Here is a picture I would like you to look at. Look at it very carefully and remember what it looks like." Then E turned to the second display on the next page where the target item again appeared but among other geometric figures varying in color, shape, and size. "Now point to the one (picture) you saw before." The target item was left in the same orientation to S as when it was initially displayed. Subject was not permitted to turn back to the initial display after it had been shown.

The task was comprised of eight test items of increasing difficulty. Level of difficulty was manipulated according to the number of nonexamples (4, 7, or 10) which were used in each of the second test displays and according to the number of dimensions (color, shape, size) on which non-examples varied from the target item. The test items used to assess concept attainment at the concrete level are shown in Appendix A.

Identity Task. This task was developed by Klausmeier, Ingison, Sipple, and Katzenmeyer (1973) to assess attainment of the concept of equilateral triangle at the identity level. The procedure followed for this task was similar to the concrete. The E presented a target item for 5 seconds. Again each item was a line drawn equilateral triangle. While S viewed the target, E said, "Here is a picture I would like you to look at. Look at it very carefully and remember what it looks like." Then E turned to the next page where the second display appeared showing the target in a different orientation with respect to S than when it was initially displayed. Nonexamples of varying colors, shapes, and sizes also appeared in the second display. "Now point to the one (picture) you saw before." Subject was not permitted to look back at the initial display after it had been shown.

The task was comprised of eight test items of increasing difficulty. Again, as in the concrete task, level of difficulty was manipulated according to the number of nonexamples (4, 7, or 10) which were used in each of the second test displays and according to the number of dimensions (color, shape, size) on which nonexamples varied from the target items. The test items used to assess concept attainment at the identity level are shown in Appendix A.

Classificatory Task. In this task, the S's attainment of the concept of equilateral triangle was assessed at the classificatory level. This task was also developed by Klausmeier, Ingison, Sipple, and Katzenmeyer (1973) although the presentation format was modified substantially. Items were presented successively, first with the target appearing, followed next by an array of examples and nonexamples from which a sort was to be made. This preferred format was believed to be more consistent with the classificatory task employing geometric blocks (as described above) and it was believed to present a more comprehensive test of the classificatory level by tapping the remembering operation as outlined in the CLD model (see Figure 4). A simultaneous presentation format of the target with the array is usually followed in administration of this task.

To begin the task, E presented a target for 5 seconds. This was a line drawn equilateral triangle. While S viewed the item, E said, "Here is a picture I would like you to look at. Look at it very carefully and remember what it looks like." The target was then concealed from S's view and the array was shown. The array consisted of drawings of geometric figures varying in color, shape, and size. "Now point to all the ones (pictures) that have the same shape as the one you saw before." Subject was not permitted to look back at the target.

This task required five sortings of increasing difficulty. On Sorts 1-3, level of difficulty was manipulated according to the number of items included in the array. For Sort 1, five items were included in the array of which two had to be selected; for Sort 2, twelve items were included of which three had to be selected; and for Sort 3, twenty-four items were included of which six had to be selected. On Sorts 4 and 5, S had to make his selection or sort on two dimensions. For Sort 4, E said, "Now point to all the ones (pictures) that have the same shape and same color as the one you saw before." Directions for Sort 5 read: "Now point to all the ones (pictures) that have the same shape and the same size as the one you saw before. There were seventeen examples and nonexamples in Sort 4 and 5, two of which had to be chosen for each sort. These consisted of triangles of various sizes. The test items used to assess concept attainment at the classificatory level appear in Appendix A.

Scoring of the Data

All S's responses on the concept assessment tasks were scored as correct or incorrect. A separate tabulation was made of the number of correct responses for each S on each of the tasks. For the concrete, identity, and classificatory tasks (Geometric Blocks) used to assess near transfer, each S received a score of 1 if he responded correctly on a given trial, or 0 if he responded incorrectly. No responses were scored as incorrect. Thus, for each of these tasks, the total possible score was 4 since four trials were involved.

Similarly, on the concrete, identity, and classificatory tasks (Two-Dimensional forms) used to assess far transfer, each S received a score of 1 or 0 for each trial. The total possible score was 8 for the concrete and identity tasks and 5 for the classificatory task. No responses were again scored as incorrect.

Apart from the correct-incorrect response data, latency measures were taken on each S during the concrete and identity trials used to measure near transfer of training. Response Time (RT) on these trials was measured with a stopwatch from the onset of the second presentation of stimuli (second display) to the time a response (i.e., pointing to a block) had been made. Unusually long RTs (more than three standard deviations above the mean of a particular S's distribution of latencies in a given treatment condition) were excluded from analysis.

Design and Statistical Analysis

The design for this experiment was a 2 x 2 x 5 factorial with six dependent measures being taken. Treatment (Conditions I, II, III, IV, or V) was the independent variable in this experiment, while age (3-years or 5-years) and sex (male or female) were included as stratifying variables. The six dependent measures employed were the number of correct responses on the two sets of concrete, identity, and classificatory tasks. The 2 x 2 x 5 design is illustrated in Table 3.

Six univariate 3-way analyses of variance (ANOVAs) were used to test main effects due to treatment, age, and sex, as well as to test for interactions between factors. These analyses were performed using a multivariate (Finn, 1968) computer program. In post hoc analyses, Tukey's (1949) test was applied in making all pairwise comparisons between conditions. Scheffé's (1953) test was also applied in making

Table 3

Factorial Design of Experiment

		AGE 3		AGE 5	
		MALE	FEMALE	MALE	FEMALE
TREATMENT	Condition I	$S_1 \vdots S_5$	$S_{26} \vdots S_{30}$	$S_{51} \vdots S_{55}$	$S_{76} \vdots S_{80}$
	Condition II	$S_6 \vdots S_{10}$	$S_{31} \vdots S_{35}$	$S_{56} \vdots S_{60}$	$S_{81} \vdots S_{85}$
	Condition III	$S_{11} \vdots S_{15}$	$S_{36} \vdots S_{40}$	$S_{61} \vdots S_{65}$	$S_{86} \vdots S_{90}$
	Condition IV	$S_{16} \vdots S_{20}$	$S_{41} \vdots S_{45}$	$S_{66} \vdots S_{70}$	$S_{91} \vdots S_{95}$
	Condition V	$S_{21} \vdots S_{25}$	$S_{46} \vdots S_{50}$	$S_{71} \vdots S_{75}$	$S_{96} \vdots S_{100}$

a more complex comparison between Conditions $\overline{1 + 5}$ and $\overline{2 + 3 + 4}$. The Type I error rate for testing all main effects and interactions was established at the .001 level, thereby maintaining an overall α of approximately .05 for the 42 tests subsumed under the six ANOVAs. This is in accordance with a strategy suggested by Miller (1966) and is frequently advocated in the psychological literature (McHugh & Ellis, 1955; Ryan, 1959, 1960, 1962; Wilson, 1962) as a means of reducing the likelihood of Type I errors when performing multiple F tests.

Chapter IV

RESULTS

The results of the present study are reported in this chapter according to task. Results of the tasks used to assess near transfer of training are presented first, followed by the results of the tasks used to assess far transfer. Latency data and the error analysis for the concrete and identity tasks using geometric blocks are also reported in this chapter.

Concept Assessment Battery - Geometric Blocks

Concrete Task (Task I)

This task was used to measure the effects of training at the concrete level of concept attainment. Subjects were required to recognize particular instances of the concept of equilateral triangle in a regular orientation after these instances were dispersed in an array among other examples and nonexamples of the concept. The assessment materials for this task, as well as for the identity and classificatory tasks which follow, consisted of geometric blocks (see Table 1) from the training sessions. The mean number of correct responses for each age x sex x treatment condition on the concrete task is shown in Table 4. The number of correct responses for individual Ss can be found in Appendix B.

Table 4

Mean Number of Correct Responses on Task I Using Geometric Blocks as a Function of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years	.50	1.80	2.30	2.30	.40
(mean = 1.46)	(.71)	(1.48)	(.95)	(1.06)	(.52)
5-Years	2.50	3.10	3.20	3.80	2.50
(mean = 3.02)	(1.43)	(.99)	(.63)	(.42)	(.85)
SEX					
Male	1.10	2.20	2.90	3.00	1.30
(mean = 2.10)	(1.37)	(1.62)	(.74)	(1.25)	(1.06)
Female	1.90	2.70	2.60	3.10	1.60
(mean = 2.38)	(1.60)	(1.16)	(1.08)	(.99)	(1.51)
TOTAL	1.50	2.45	2.75	3.05	1.45

Note.--Standard deviations are given in parentheses.

Figure 9 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

The results of the univariate analysis of variance are presented in Table 5. Statistically significant results were found for age and for treatment. Five-year-old Ss (3.02) gave a higher mean number of correct responses on the concrete task than 3-year-old Ss (1.46).

The effects due to treatment were analyzed by post hoc comparisons among means. Table 6 shows the results of this analysis. The mean number of correct responses in treatment Conditions 2, 3, and 4 (2.75) was found to be significantly higher than in Conditions 1 and 5 (1.48). Those conditions involving manual activity and verbal orienting instruction were relatively better than those involving visual inspection and unrelated play activity (control). Pairwise comparisons between Conditions 1 and 2 and between Conditions 2, 3, and 4 were not found to be significant. A look at the means in Table 4 indicates that Condition 4 (3.05) was relatively more facilitating in recognizing particular instances of the concept at the concrete level. Condition 3 (2.75) was relatively more facilitating than Condition 2 (2.45), while Condition 1 (1.50) was relatively more facilitating than Condition 5 (1.45). Again, however, pairwise comparisons were not found to be significant at the reduced α level.

Sex was not a significant source of influence on the concrete task, although in looking at the means (see Table 4) one sees that girls (2.38) tend to do better than boys (2.10) for the various treatment conditions.

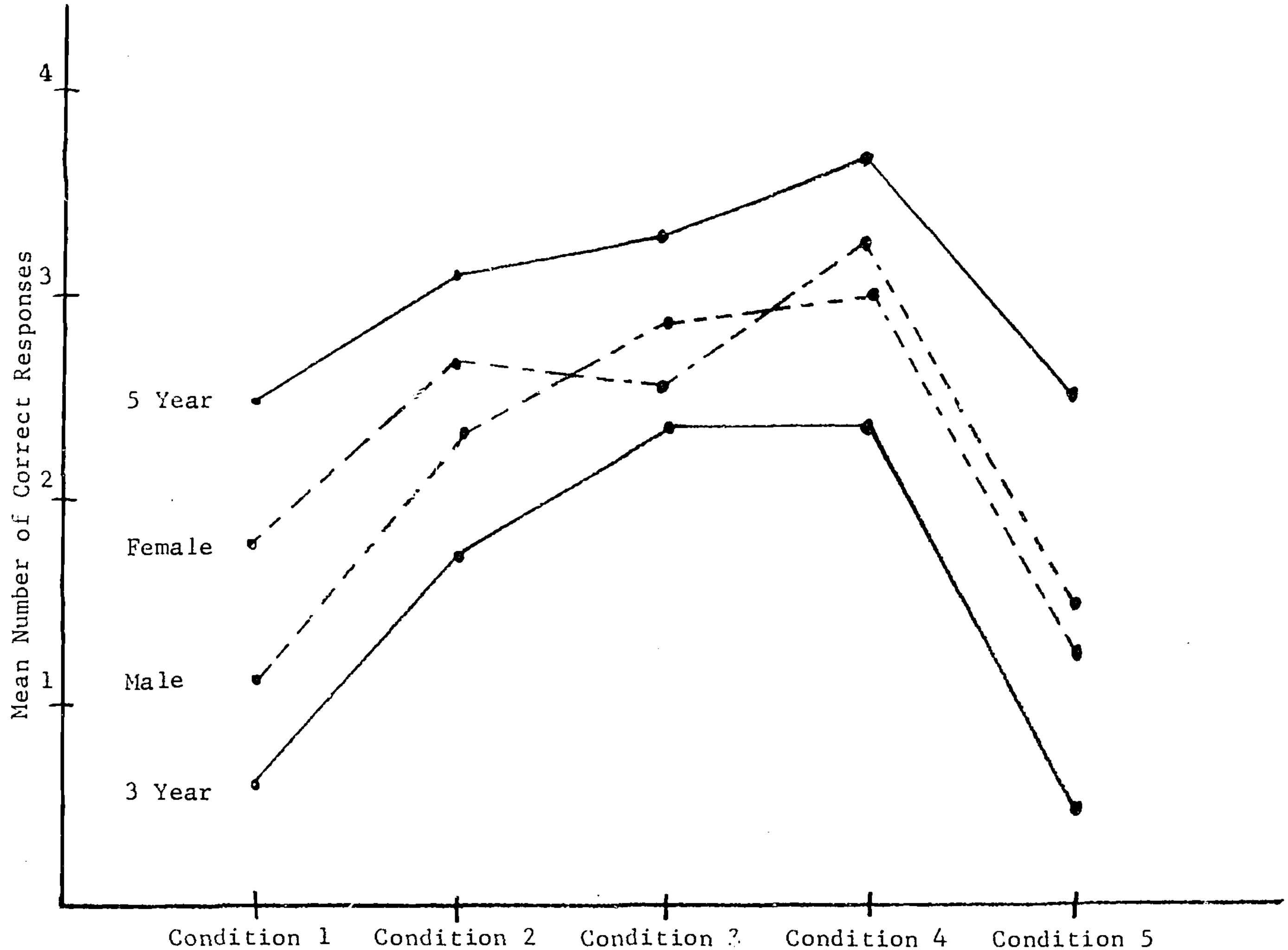


Figure 9. Mean number of correct responses according to age and sex for the various treatment conditions on Task I (Geometric Blocks).

Table 5

Univariate Analysis of Variance for Total Number of Correct Responses on Task I Using Geometric Blocks

Source	df	F	Probability
Age (A)	1,80	66.49	<.0001*
Sex (S)	1,80	2.14	<.1473
Treatment (T)	4,80	11.65	<.0001*
A x S	1,80	1.57	<.2134
A x T	4,80	1.36	<.2570
S x T	4.80	.94	<.4454
A x S x T	4,80	1.03	<.3984

*p < .001

Table 6

Post Hoc Comparisions Among Treatment Means in Task I Using Geometric Blocks

		Group 1	2	3	4	5
(Tukey HSD = 1.61)		Mean 1.50	2.45	2.75	3.05	1.45
Group	Mean					
1	1.50	——	.95	1.25	1.55	-.05
2	2.45		——	.30	.60	-1.00
3	2.75			——	.30	-1.30
4	3.05				——	-1.60
5	1.45					——

(Scheffé S = .89)

Groups 1 + 5 (1.48) vs. Groups 2 + 3 + 4 (2.75) = 1.27*

*p < .001

Lastly, no significant interactions occurred between factors.

Identity Task (Task II)

In this task, Ss were required to recognize particular instances of the concept of equilateral triangle in an orientation that was different from the initial showing. The mean number of correct responses for each age x sex x treatment condition on the identity task is presented in Table 7. Response data of individual Ss can also be found in Appendix B.

Figure 10 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

The results of the analysis of variance of the mean number of responses which were correct on Task II are shown in Table 8. As in Task I, statistically significant results were obtained for age and for treatment. Five-year-olds (2.84) scored a greater mean number of correct responses than 3-year-olds (1.36).

Post hoc comparisons among treatment means revealed significant differences between Conditions 1, 5 (1.43) and 2, 3, 4 (2.55). The comparisons among means are shown in Table 9. Again, those conditions which emphasized manual activity and verbal orienting instruction were relatively more effective than the visual condition and the control. Overall, Condition 4 (2.80) appeared to be the most facilitating condition, followed by Conditions 2 (2.50) and 3 (2.35). Of the least

Table 7

Mean Number of Correct Responses on Task II
Using Geometric Blocks as a Function
of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years	.40	1.60	1.70	2.70	.40
(mean = 1.36)	(.52)	(1.51)	(.95)	(1.06)	(.70)
5-Years	2.20	3.40	3.00	2.90	2.70
(mean = 2.84)	(1.48)	(.52)	(.94)	(.88)	(.82)
SEX					
Male	.70	2.40	2.50	2.70	1.50
(mean = 1.96)	(1.06)	(1.43)	(.85)	(.82)	(1.23)
Female	1.90	2.60	2.20	2.90	1.60
(mean = 2.24)	(1.52)	(1.51)	(1.40)	(1.10)	(1.58)
TOTAL	1.30	2.50	2.35	2.80	1.55

Note.--Standard deviations are given in parentheses.

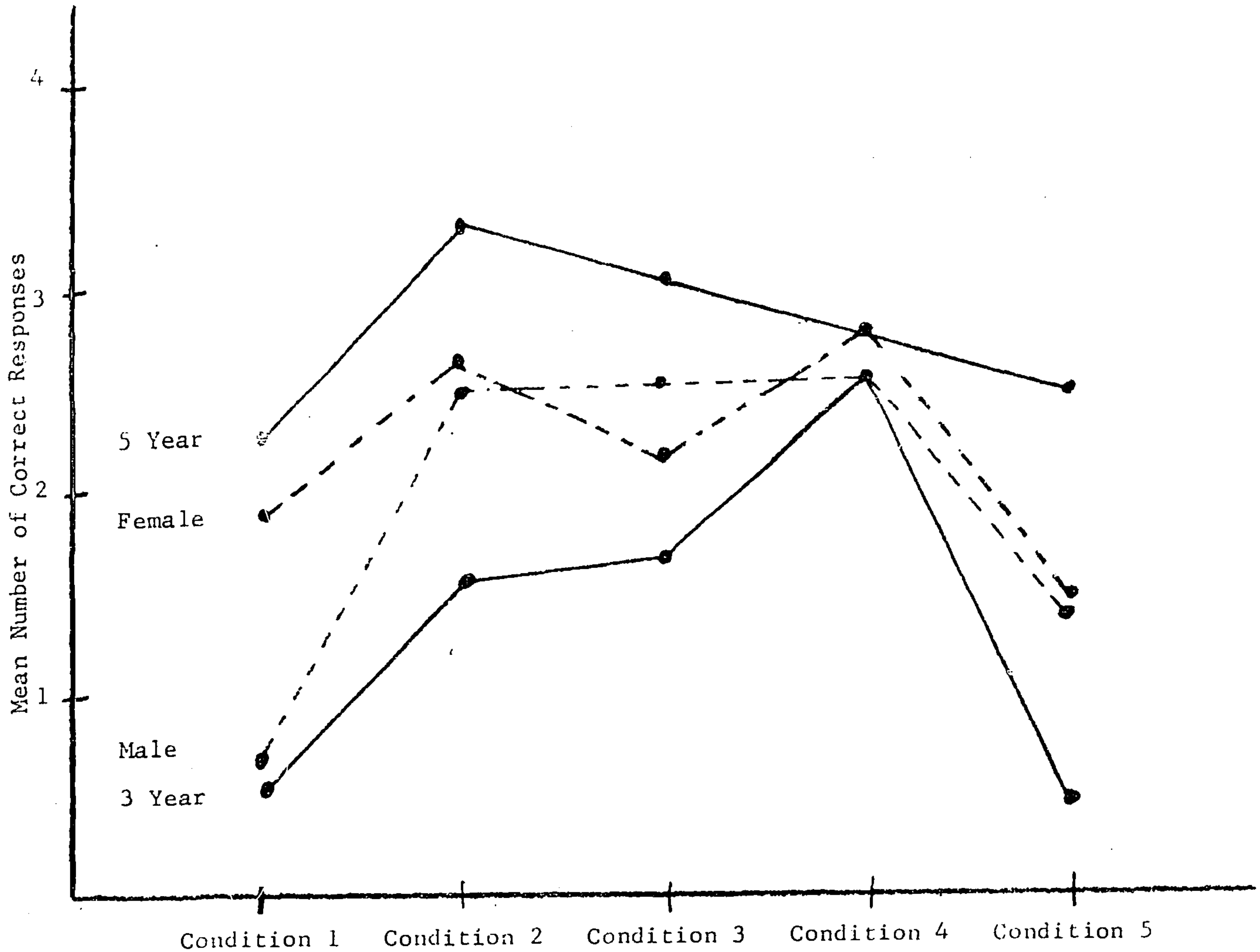


Figure 10. Mean number of correct responses according to age and sex for the various treatment conditions on Task II (Geometric Blocks).

Table 8

Univariate Analysis of Variance for Total Number of Correct Responses on Task II Using Geometric Blocks

Source	df	F	Probability
Age (A)	1,80	58.26	<.0001*
Sex (S)	1,80	2.09	<.1527
Treatment (T)	4,80	19.48	<.0001*
A x S	1,80	3.45	<.0671
A x T	4,80	3.39	<.0130
S x T	4,80	1.63	<.1741
A x S x T	4,80	.49	<.7397

*p < .001

facilitating conditions, Condition 5 (1.55) seemed to be better than Condition 1 (1.30). Pairwise differences between treatment conditions however were not significant.

The main effect of sex was not significant. However, the mean number of correct responses for girls (2.24) was higher than for boys (1.96).

Although none of the interactions approached the .001 significance level, 3-year-olds seem to perform better in Condition 4 while 5-year-olds seem to perform better in Condition 2 (age x treatment, NS $p < .01$). This finding is in accord with the CLD model, which holds that with increasing age a child relies more on verbal functions as a means of attaining concepts.

Classificatory Task (Task III)

On Sorts 1-3 of this task, Ss were asked to select from an array blocks having the same shape as the concept example. On Sort 4, Ss were asked to pick out blocks of the same shape and color as the concept example. In each case, the concept example was an equilateral triangle. The mean number of correct responses on the classificatory task is shown in Table 10 for each age x sex x treatment condition. Response data for individual Ss are found in Appendix B.

Figure 11 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

Table 9

Post Hoc Comparisons Among Treatment Means in Task II Using Geometric Blocks

		Group 1	Group 2	Group 3	Group 4	Group 5
(Tukey HSD = 1.65)				Mean		
		1.30	2.50	2.35	2.80	1.55
Group	Mean					
1	1.30	——	1.20	1.05	1.50	.25
2	2.50		——	-.15	.30	-.95
3	2.35			——	.45	-.80
4	2.80				——	-1.25
5	1.55					——

(Scheffé S = .77)

Groups 1 + 5 (1.43) vs. Groups 2 + 3 + 4 (2.55) = 1.12*

*$p < .001$

Table 10

Mean Number of Correct Responses on Task III
Using Geometric Blocks as a Function
of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years (mean = 1.08)	.10 (.30)	1.70 (1.62)	1.00 (1.18)	2.60 (1.43)	.00 (.00)
5-Years (mean = 1.90)	.70 (1.00)	2.70 (1.49)	2.40 (1.56)	3.30 (.78)	.40 (.92)
SEX					
Male (mean = 1.36)	.30 (.90)	1.50 (1.57)	1.60 (1.50)	3.30 (.90)	.10 (.30)
Female (mean = 1.62)	.50 (.67)	2.90 (1.37)	1.80 (1.60)	2.60 (1.36)	.30 (.90)
TOTAL	.40	2.20	1.70	2.95	.20

Note.--Standard deviations are given in parentheses.

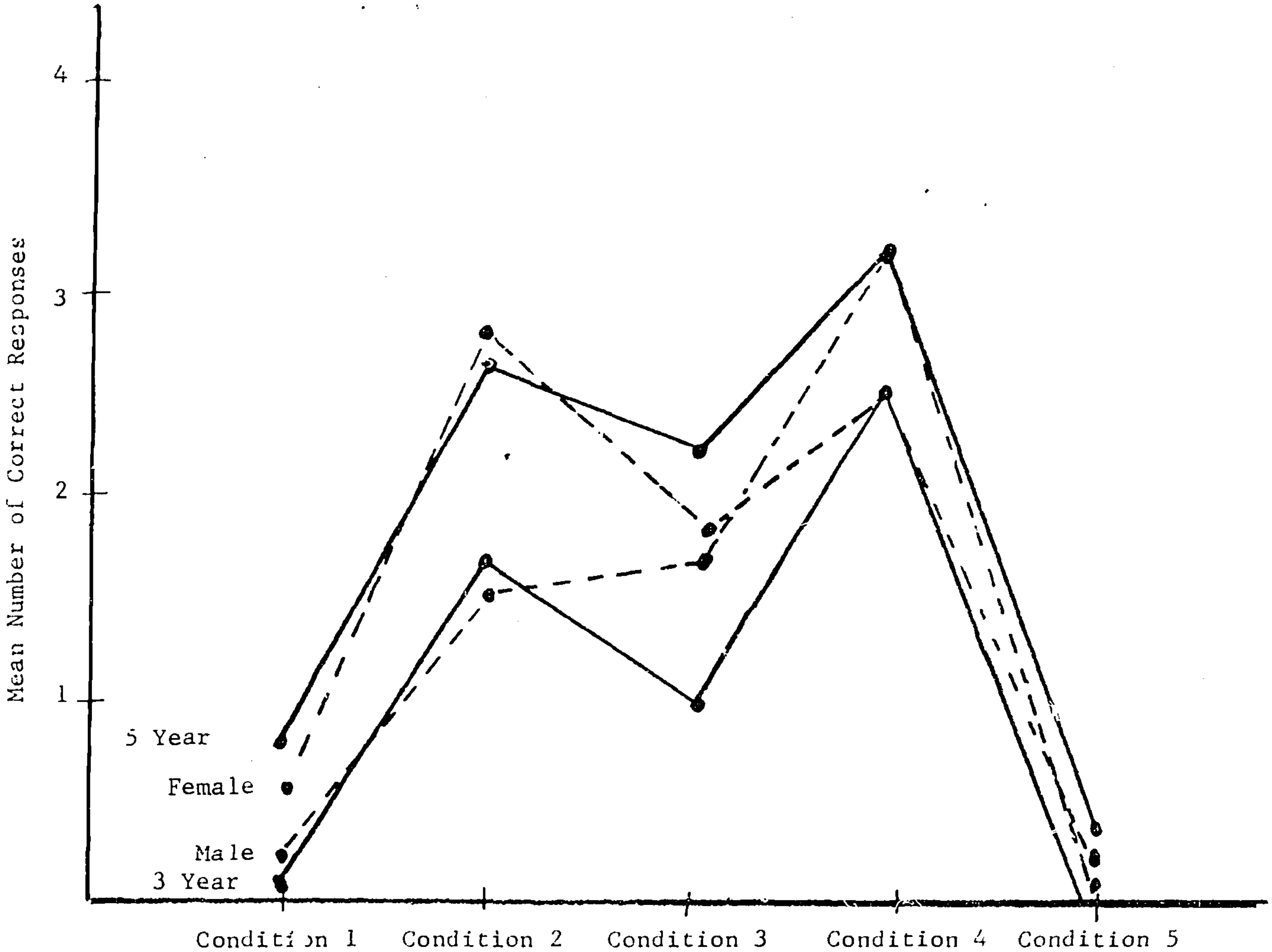


Figure 11. Mean number of correct responses according to age and sex for the various treatment condition. on Task III (Geometric Blocks).

Table 11 summarizes the results of the univariate analysis of variance. As may be noted in this table, age and treatment were again shown to be significant at the designated level. Five-year-old Ss (1.90) scored a higher mean number of correct responses than 3-year-olds (1.08), while Conditions 2 (2.20), 3 (1.70), and 4 (2.95) were relatively more facilitating than Conditions 1 (.40) and 5 (.20).

Table 12 also indicates that there were significant differences between various treatments. Pairwise comparisons revealed that the mean number of correct responses in Condition 2 (2.20) was significantly higher than in Condition 1 (.40), and significantly higher than in Condition 5 (.20). Furthermore, each of Conditions 2 (2.20) and 4 (2.95) were significantly better than Condition 5 (.20). These data clearly demonstrate that verbal training in Conditions 2 and 4 is more facilitating to concept attainment at the classificatory level than the type of training in Condition 1 (visual) or Condition 5 (control). The result of the complex comparison between $\overline{1 + 5}$ (.30) and $\overline{2 + 3 + 4}$ (2.28) indicates the general superiority of verbal orienting instruction and manual activity--particularly when combined--over visual and unrelated play activity.

Sex was not a significant factor although girls (1.62) performed somewhat better than boys (1.36). No significant interactions were found between factors on the classificatory task.

Table 11

Univariate Analysis of Variance for Total Number of Correct Responses on Task III Using Geometric Blocks

Source	df	F	Probability
Age (A)	1,80	11.83	.0010*
Sex (S)	1,80	1.19	.2786
Treatment (T)	4,80	19.48	.0001*
A x S	1,80	2.04	.1576
A x T	4,80	.54	.7103
S x T	4,80	1.96	.1079
A x S x T	4,80	.56	.6950

*p < .001

Table 12

Post Hoc Comparisons Among Treatment Means in Task III Using Geometric Blocks

		Group 1	Group 2	Group 3	Group 4	Group 5
(Tukey HSD = 1.63)	Mean	.40	2.20	1.70	2.95	.20
Group	Mean					
1	.40	—	1.80*	1.30	2.55*	-.20
2	2.20		—	-.50	.75	-2.00*
3	1.70			—	1.25	-1.50
4	2.95				—	-2.75*
5	.20					—

(Scheffé S = 1.38)

Groups 1 + 5 (.30) vs. Groups 2 + 3 + 4 (2.28) = 1.98*

*p < .001

Concept Assessment Battery--Two-Dimensional Geometric Forms

Concrete Task (Task I)

This task was used to measure transfer of training at the concrete level of concept attainment. Different from the above tasks employing geometric blocks, this task required Ss to recognize particular instances of the concept of equilateral triangle using two-dimensional drawings. For the concrete level, Ss were required to respond to the same instances when presented in their regular orientation. The assessment materials for this task and for the identity and classificatory tasks which follow can be found in Appendix A. Table 13 gives the mean number of correct responses for each age x sex x treatment condition on the concrete task. The number of correct responses for individual Ss is contained in Appendix C.

Figure 12 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

The analysis of variance as seen in Table 14 revealed significant main effects for age and treatment. The mean number of correct responses was significantly higher in the 5-year-old age group (7.28) than in the 3-year-old age group (4.38).

Post hoc comparisons calculated for treatment groups are presented in Table 15. Only the comparison between $\overline{1 + 5}$ and $\overline{2 + 3 + 4}$ was significant at the designated level. A larger mean number of correct responses was given in conditions entailing manual activity and verbal orienting instruction (6.53) than in conditions entailing visual in-

Table 13

Mean Number of Correct Responses on Task I
Using Two-Dimensional Geometric Forms
as a Function of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years	3.00	5.30	5.50	5.10	3.00
(mean = 4.38)	(1.41)	(2.37)	(1.43)	(1.70)	(1.34)
5-Years	6.90	7.50	7.20	7.60	7.20
(mean = 7.28)	(1.04)	(.67)	(.75)	(.49)	(.60)
SEX					
Male	4.40	5.50	6.50	6.40	5.50
(mean = 5.66)	(2.41)	(2.42)	(1.30)	(1.56)	(2.25)
Female	5.50	7.30	6.20	6.30	4.70
(mean = 6.00)	(2.06)	(1.00)	(1.47)	(1.95)	(2.41)
TOTAL	4.95	6.40	6.35	6.35	5.10

Note.--Standard deviations are given in parentheses.

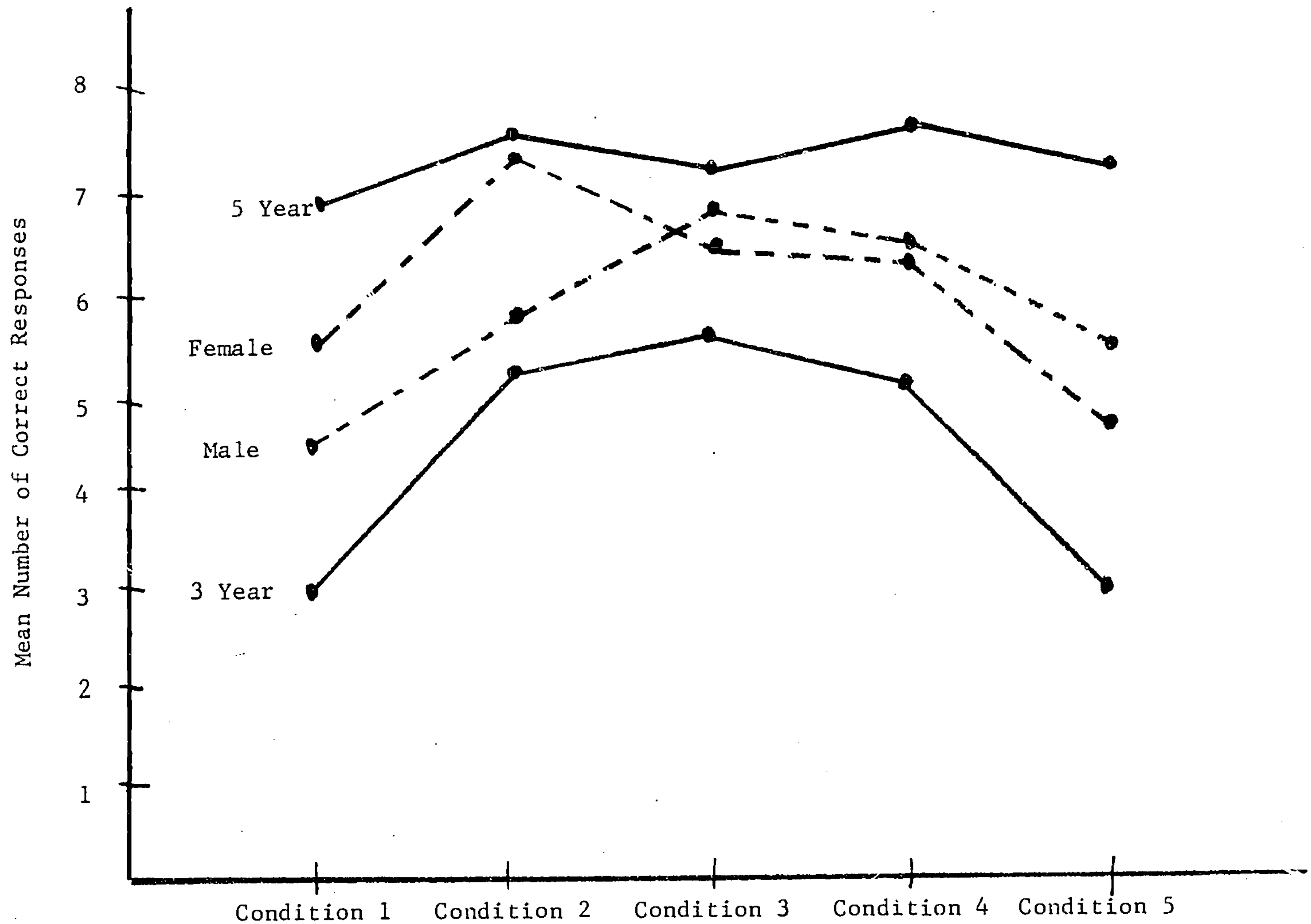


Figure 12. Mean number of correct responses according to age and sex for the various treatment conditions on Task I (Two-Dimensional Geometric Forms).

Table 14

Univariate Analysis of Variance for Total Number of Correct Responses on Task I Using Two-Dimensional Geometric Forms

Source	df	F	Probability
Age (A)	1,80	123.31	<.0001*
Sex (S)	1,80	1.70	<.1967
Treatment (T)	4,80	6.37	<.0002*
A x S	1,80	.99	<.3225
A x T	4,80	3.50	<.0110
S x T	4,80	3.38	<.0132
A x S x T	4,80	1.24	<.3006

*p < .001

spection and unrelated play activity (5.18). None of the pairwise differences between treatment conditions were significant.

There was no significant effect due to sex, although girls (6.00) scored somewhat higher than boys (5.66). No significant interactions occurred. Marginal results were obtained, however, in the age x treatment interaction and in the sex x treatment interaction. In examining the means in Table 13, there was some tendency for the 3-year-olds to perform better with manual kinds of activity while 5-year-olds seemed to perform better with verbal orienting instruction. This finding is consistent with the CLD model which states that as children become older they depend increasingly on verbal functions as a means of acquiring concepts at different levels.

As for the sex x treatment interaction, girls seemed to perform better in Conditions 1 and 2 while boys seemed to perform better in Conditions 3, 4, and 5.

Identity Task (Task II)

In this task, Ss were asked to respond to particular concept instances of equilateral triangle in an orientation that was different from the initial display. Two-dimensional drawings of geometric forms represented the stimuli for this task. Table 16 presents the mean number of correct responses for the various conditions on the identity task. The number of correct responses for individual Ss is tabled in Appendix C.

Table 15

Post Hoc Comparisons Among Treatment Means in Task I Using Two-Dimensional Geometric Forms

		Group 1	2	3	4	5
(Tukey HSD = 3.17)				Mean		
		4.95	6.40	6.35	6.35	5.10
Group	Mean					
1	4.95	—	1.45	1.40	1.40	.15
2	6.40		—	-.05	-.05	-1.30
3	6.35			—	.00	-1.25
4	6.35				—	-1.25
5	5.10					—

(Scheffé S = .75)

Groups 1 + 5 (5.18) vs. Groups 2 + 3 + 4 (6.53) = 1.35*

*p < .001

Figure 13 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

Results of the univariate analysis of variance in Table 17 indicate significant effects due to age and treatment. One again 5-year-olds (7.10) are shown to perform better than 3-year-olds (4.48).

Post hoc comparisons among treatment means in Table 18 also indicate that Conditions 2, 3, and 4 (6.48) are significantly better than Conditions 1 and 5 (5.08) on the identity task. Pairwise differences between treatment means were not significant, but inspection of Table 16 shows that the mean number of correct responses is highest in the visual + manipulation + verbal condition (6.90) and lowest in the control group (4.70).

Girls (6.04) again performed better than boys (5.54) although these differences were not found to be significant. Interactions

Table 16

Mean Number of Correct Responses on Task II
Using Two-Dimensional Geometric Forms
as a Function of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years	3.20	4.40	5.80	6.20	2.80
(mean = 4.48)	(2.04)	(2.65)	(1.72)	(1.54)	(1.08)
5-Years	6.40	7.60	7.30	7.60	6.60
(mean = 7.10)	(1.43)	(.66)	(1.64)	(.66)	(1.43)
SEX					
Male	4.00	5.30	6.70	6.80	4.90
(mean = 5.54)	(2.65)	(3.07)	(1.68)	(1.17)	(2.12)
Female	5.60	6.70	6.40	7.00	4.50
(mean = 6.04)	(1.74)	(1.49)	(1.28)	(1.55)	(2.42)
TOTAL	4.80	6.00	6.55	6.90	4.70

Note.--Standard deviations are given in parentheses.

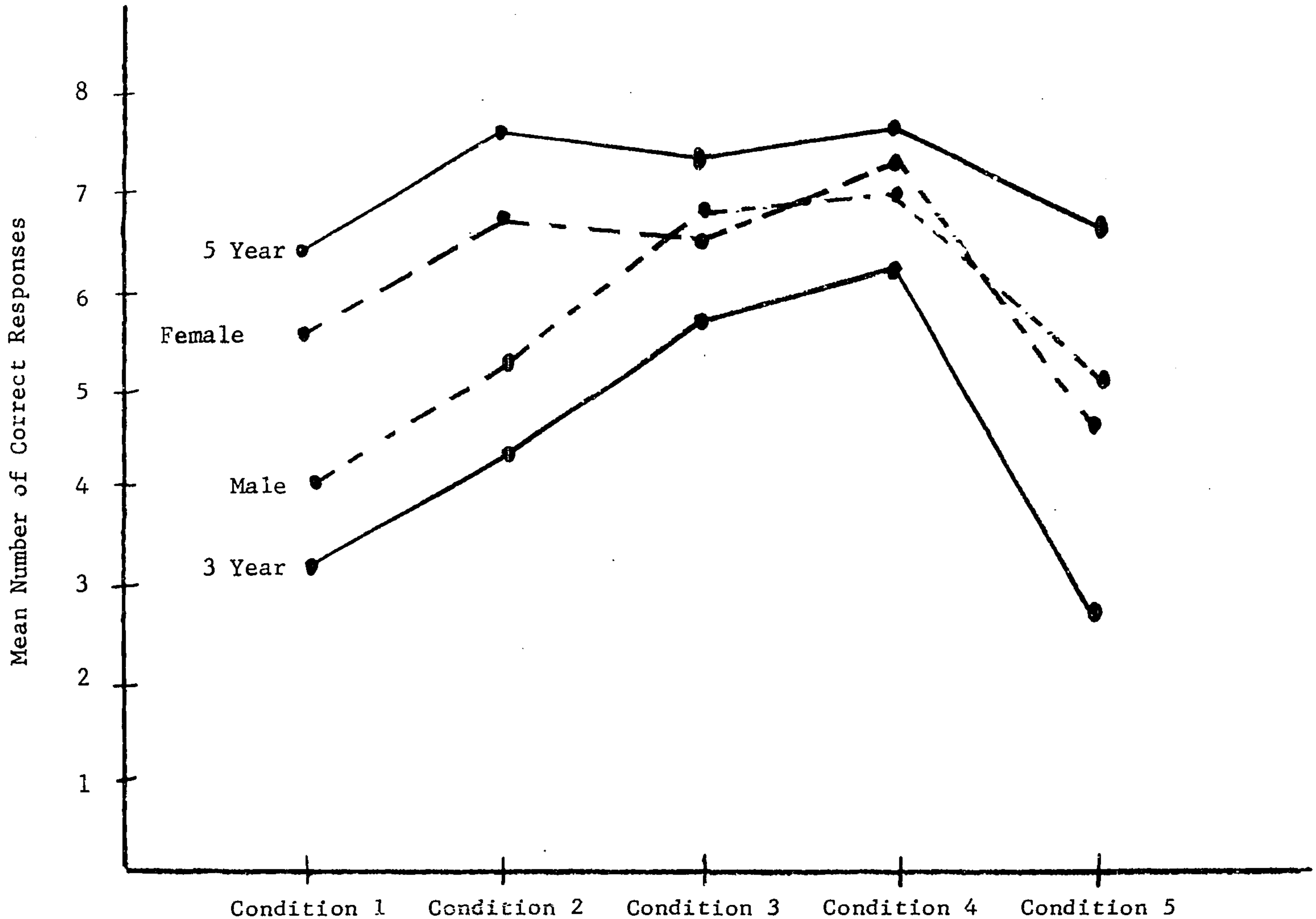


Figure 13. Mean number of correct responses according to age and sex for the various treatment conditions on Task II (Two-Dimensional Geometric Forms).

Table 17

Univariate Analysis of Variance for Total Number of Correct Responses on Task II Using Two-Dimensional Geometric Forms

Source	df	F	Probability
Age (A)	1,80	73.97	<.0001*
Sex (S)	1,80	2.70	<.1047
Treatment (T)	4,80	8.67	<.0001*
A x S	1,80	2.28	<.1350
A x T	4,80	2.59	<.0428
S x T	4,80	1.92	<.1155
A x S x T	4,80	1.68	<.1636

*p < .001

Table 18

Post Hoc Comparisons Among Treatment Means in Task II Using Two-Dimensional Geometric Forms

		Group 1	Group 2	Group 3	Group 4	Group 5
(Tukey HSD = 2.72)				Mean		
		4.80	6.00	6.55	6.90	4.70
Group	Mean					
1	4.80	——	1.20	1.75	2.10	-.10
2	6.00		——	.55	.90	-1.30
3	6.55			——	.35	-1.85
4	6.90				——	-2.20
5	4.70					——

(Scheffé S = 1.20)

Groups 1 + 5 (5.08) vs. Groups 2 + 3 + 4 (6.48) = 1.40*

*p < .001

were also not significant; however, a marginal result was obtained in the age x treatment interaction. Three-year-olds seemed to be better as a result of manual activity and the combination of manual activity and verbal orienting instruction. Five-year-olds appeared to do better as a result of verbal orienting instruction and the combination of manual activity and verbal orienting instruction. This is an important finding with respect to the CLD model which states that with increasing age verbal functions are increasingly relied upon as a means of attaining concepts.

Classificatory Task (Task III)

As noted in the "Method" chapter, the classificatory level task consisted of five sorts. On Sorts 1-3, Ss were required to pick out geometric forms which were similar in shape to the concept example; Sort 4 required a selection on the basis of same shape and same color; Sort 5 required a selection on the basis of same shape and same size.

The task consisted of line drawn geometric figures and scores were assigned on the basis of correct sorts. Table 19 shows the mean number of correct responses for each age x sex x treatment condition. The response data for individual Ss appear in Appendix C.

Figure 14 illustrates the mean scores according to age and according to sex for each of the treatment conditions.

Table 19

Mean Number of Correct Responses on Task III
Using Two-Dimensional Geometric Forms
as a Function of Age, Sex, and Treatment

	TREATMENT				
	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
AGE					
3-Years	.50	1.30	1.00	1.70	.30
(mean = .96)	(.67)	(1.49)	(1.18)	(1.40)	(.46)
5-Years	1.20	2.90	3.30	3.00	.90
(mean = 2.26)	(1.17)	(.94)	(1.19)	(.63)	(.83)
SEX					
Male	.30	1.70	2.30	2.60	.60
(mean = 1.50)	(.46)	(1.35)	(1.79)	(1.02)	(.66)
Female	1.40	2.50	2.00	2.10	.60
(mean = 1.72)	(1.11)	(1.28)	(1.48)	(1.40)	(.66)
TOTAL	.85	2.10	2.15	2.35	.60

Note.--Standard deviations are given in parentheses.

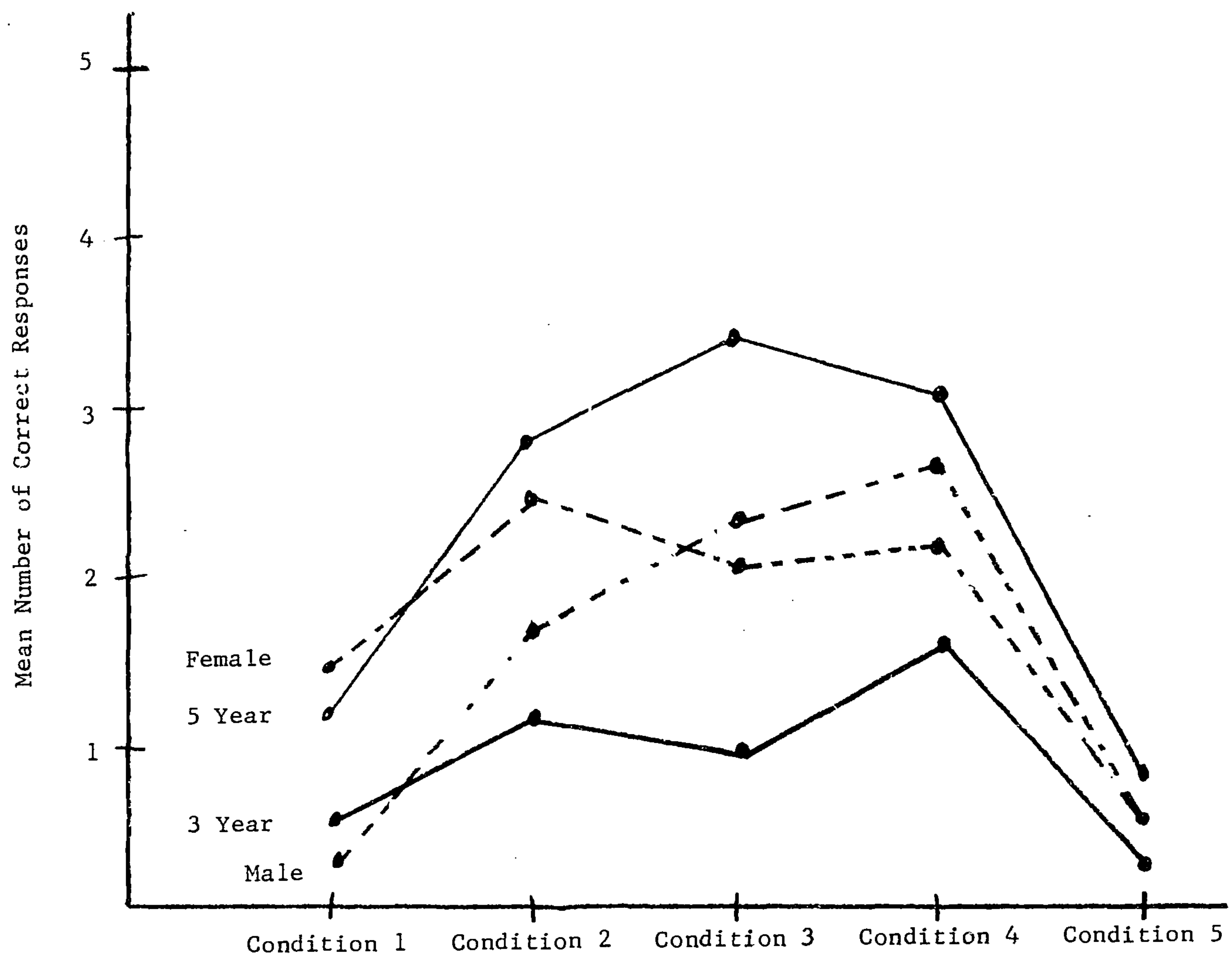


Figure 14. Mean number of correct responses according to age and sex for the various treatment conditions of Task III (Two-Dimensional Geometric Forms).

The results of the analysis of variance as shown in Table 20 revealed significant differences due to age and treatment. Five-year-old Ss (2.36) gave a significantly larger number of correct responses on the classificatory task than 3-year-olds (.96). Conditions 2, 3, and 4 (2.20) were significantly more effective than Conditions 1 and 5 (.73).

Table 20

Univariate Analysis of Variance for Total Number of Correct Responses on Task III Using Two-dimensional Geometric Forms

Source	df	F	Probability
Age (A)	1,80	36.74	<.0001*
Sex (S)	1,80	1.05	<.3081
Treatment (T)	4,80	11.64	<.0001*
A x S	1,80	1.05	<.3081
A x T	4,80	2.11	<.0874
S x T	4,80	2.12	<.0863
A x S x T	4,80	.47	<.7611

*p < .001

Post hoc comparisons in Table 21 also revealed a significant pairwise difference between Condition 4 and Condition 5. Condition 4 (2.35) was significantly more facilitating on the classificatory task than Condition 5 (.60). In general, the visual + manipulation + verbal was the most potent condition for classificatory training, the control and the visual only were the least potent.

Table 21

Post Hoc Comparisons Among Treatment Means in Task III Using Two-Dimensional Geometric Forms

		Group 1	2	3	4	5
(Tukey HSD = 1.61)				Mean		
		.85	2.10	2.15	2.35	.60
Group	Mean					
1	.85	——	1.25	1.30	1.53	- .25
2	2.10		——	.05	.25	-1.50
3	2.15			——	.20	-1.55
4	2.35				——	-1.75*
5	.60					——

(Scheffé S = 1.02)

Groups 1 + 5 (.73) vs. Groups 2 + 3 + 4 (2.20) = 1.47*

*$p < .001$

No significant differences occurred in the factor of sex although girls (1.72) generally did better than boys (1.50). In addition, none of the interactions were significant.

Error Analysis

Data collected on the concrete and identity tasks using geometric blocks were reexamined in order to ascertain what kinds of errors had been committed in the various age x treatment conditions. As pointed out earlier, these two tasks were uniquely constructed in such a manner that the target block for each trial always differed from each of the nonexamples on one characteristic, either on the basis of shape, color, size, or thickness. Therefore it was possible to determine which dimensions Ss were not attending to when making an incorrect judgment (i.e., when selecting one of the nonexamples).

The proportion of incorrect responses on the four stimulus dimensions is presented in Table 22 for each age x treatment condition. In general, the 3-year-old group erred predominantly on the color dimensions. Thirty-four percent of the incorrect responses made by 3-year-olds were errors of color. Besides color, 3-year-old Ss in the visual and control groups erred more frequently on the basis of shape than on the basis of size or thickness.

However, in the more effective treatment groups (i.e., Conditions 2, 3, and 4), shape did not seem to present any real difficulty. Subjects in these treatment conditions apparently experienced more difficulty with size and thickness than with shape. Consequently, it would appear that Ss receiving manipulatory experience and verbal orienting instruction were better prepared in discriminating shapes at the concrete and identity levels, particularly in discriminating equilateral from right isosceles triangles. Those Ss who were given the visual exploratory condition and the control condition were less adequately prepared in making these finer shape discriminations.

Table 22
Proportion of Incorrect Responses on Stimulus Dimensions by Age and Treatment on the Concrete and Identity Tasks Using Geometric Blocks

	Stimulus Dimension				
	Shape	Color	Size	Thickness	Total
AGE 3					
Condition 1	.25	.31	.19	.13	.88
Condition 2	.08	.33	.13	.04	.58
Condition 3	.06	.28	.16	.03	.50
Condition 4	.01	.22	.02	.13	.38
Condition 5	.17	.48	.13	.13	.90
AGE 5					
Condition 1	.14	.08	.08	.13	.41
Condition 2	.05	.11	.00	.03	.19
Condition 3	.08	.11	.00	.04	.23
Condition 4	.04	.06	.01	.05	.16
Condition 5	.20	.05	.01	.08	.34
Expected Value	.29	.29	.14	.14	.86

For the 5-year-olds, the types of error committed varied according to treatment group. To a greater extent in Condition 5 (control) and to a somewhat lesser extent in Condition 1 (visual), errors were committed primarily on the shape dimension, whereas in Conditions 2, 3, and 4 errors were primarily of the color variety. Once again, manipulatory experience and verbal orienting instruction seem to be more powerful influences in the discrimination of shape as tested by the concrete and identity tasks.

Response Latency Data

Table 23 presents the mean reaction times for Ss on the concrete and identity tasks using geometric blocks. Reaction time was measured from the moment the second display had appeared on the concrete and identity trials to the time S responded (i.e., by pointing) to one of the blocks. Only latency data for the 5-year-old Ss are reported in this table since it was very difficult to record accurately the RTs for the 3-year-olds.

Inspection of Table 23 shows a number of interesting results. First, RTs of Ss in treatment Conditions 2, 3, and 4 were longer than RTs of Ss in conditions 1 and 5. This is of particular interest in view of the fact that these three conditions were consistently more facilitating to concept attainment at the concrete, identity, and classificatory levels. Subjects in Conditions 1 and 5--the least facilitating of all the conditions--seemed to be making more hasty judgments. The implications of these findings will be explored in the "Discussion" chapter.

Table 23

Mean Reaction Time (RT) on Concrete and Identity Tasks by Treatment Condition (5-year-olds only)

	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5
Correct Responses	4.38 (2.12)	4.38 (1.97)	5.25 (3.16)	6.13 (4.78)	4.52 (2.31)
Incorrect Responses	4.50 (2.14)	5.36 (2.54)	6.25 (3.96)	9.54 (6.24)	3.77 (1.87)
Total	4.43 (2.12)	4.57 (2.10)	5.48 (3.35)	6.72 (5.18)	4.24 (2.22)

RT measured in seconds

Note.--Standard deviations are given in parentheses.

Another interesting aspect of these findings concerns the respective RTs for correct and incorrect responses. In the control group (Condition 5), RTs for incorrect responses were <u>shorter</u> than the RTs for correct responses. Yet the reverse was true in treatment Conditions 1-4. In these groups RTs for incorrect responses were <u>longer</u> than the RTs for correct responses.

In general, <u>S</u>s in Condition 4 (visual + manipulation + verbal) took the longest time in responding to concrete and identity test items. In turn, <u>S</u>s in Condition 3 took longer than <u>S</u>s in Condition 2, followed by those in Condition 1 and Condition 5. Reaction times were analyzed in a one-way analysis of variance with RT for treatment condition included as the single variate. The results, however, were not significant, $F(4, 84) = 3.60$, $p < .10$. Negative results were partly due to having a disproportionate number of observations for each treatment group.

Chapter V

DISCUSSION

Conclusions

The purpose of the present study was to investigate the relative effects of certain forms and combinations of sensory-motor training and verbal orienting instruction on early concept acquisition. Three general questions were raised at the outset of the experiment:

1. What are the effects of various combinations of visual inspection, sensory-motor training, and verbal orienting instruction on children's concept attainment at each of three levels--concrete, identity, and classificatory?
2. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to age?
3. How are the various combinations of visual inspection, sensory-motor training, and verbal orienting instruction in concept attainment related to sex?

With regard to the questions that have been raised, the following conclusions can be drawn:

1. Sensory-motor training and verbal orienting instruction were facilitating to the attainment of the concept of <u>equilateral triangle</u> at the concrete, identity, and classificatory levels. Facilitating effects were found on all three concept tasks employed in this study, both in terms of the training materials

(i.e., geometric blocks) which were used to assess near transfer at these levels and in terms of the two-dimensional geometric representations which were used to assess far transfer. Conditions 2, 3, and 4 were significantly more facilitating than Conditions 1 and 5. Post hoc analyses revealed significant pairwise differences only on the classificatory tasks. In the measure of near transfer, Condition 2 had a significantly larger mean than Condition 5. The means in each of Conditions 2 and 4 were significantly larger than Condition 5. In the measure of far transfer, Condition 4 had a significantly larger mean than Condition 5. Examination of the mean values would indicate that Condition 4 (visual + manipulation + verbal) was generally the most effective treatment. Condition 2 (visual + verbal) was generally the second most effective treatment except on the concrete task measuring near transfer and on the identity task measuring far transfer. On these two tasks Condition 3 showed a larger number of correct responses. Aside from these two tasks, Condition 3 (visual + manipulation) was generally the third most powerful treatment. Of the least facilitating conditions, there seemed to be a trade off between the visual and the control. On the concrete and classificatory tasks measuring near transfer and on the identity task measuring far transfer, the visual was a somewhat better condition. However, on the identity task measuring near transfer and on the concrete and classificatory tasks measuring far transfer, the control group seemed to be performing better than the visual.

2. Age was found to be a significant factor on each of the concept assessment tasks. Five-year-old Ss gave a significantly larger number of correct responses than 3-year-old Ss for each treatment condition. No significant interactions occurred between age and treatment at the .001 level. However, marginal results were obtained on the concrete task utilizing two-dimensional geometric forms ($p < .01$) and on both identity tasks utilizing geometric blocks ($p < .01$) and two-dimensional forms ($p < .04$). Three-year-old Ss seemed to perform better as a result of manual exploratory activity (Condition 3) or a combination of manual activity and verbal orienting instruction (Condition 4); five-year-old Ss seemed to perform better as a result of verbal orienting instruction (Condition 2).
3. There was no significant main effect of sex. However, on all of the dependent measures that were taken girls had a relatively higher mean number of correct responses than boys. A marginal effect in the sex x treatment interaction ($p < .01$) did occur on the concrete task using two-dimensional geometric representations. On this particular task boys appeared to do better than girls in Conditions 3, 4, and 5; girls appeared to do better than boys in Conditions 1 and 2.

Theoretical Implications

On the theoretical side, three important things have been demonstrated in the present investigation: (1) manual exploratory activity in the form of free haptic play and tactile-kinesthetic training can combine successfully with visual exploratory behavior in facilitating levels of concept attainment in young children; (2) verbal orienting instruction is facilitating to each of these levels of concept attainment and is particularly effective when combined with visual and manipulative experience; (3) younger children (3-years) depend more on manual exploratory activity than older children, while older children (5-years) depend more on verbal orienting instruction than younger children.

The first point is consistent with Soviet findings (Yendovitskaya, et. al., 1971; Zaporozhets, 1958, 1965) which support the notion that manual activity is important to the development of visual perception of form. It is also in contradiction with the results obtained in recent experiments by Butter and Zung (1970), DeLeon, Raskin, and Gruen (1970), and Millar (1971), which show the visual to be equivalent to the visual and haptic (or tactile).

Why the contradiction in findings? The reason for the discrepancy appears to be related partly to methodology. The nature of sensory-motor training is a critical factor. In many of the studies reporting negative results, the accounts of training are usually found to be very sketchy. Details are often ignored about how the E interacted with the S and how, specifically, manipulative exercises were performed. The only conclusion one is forced to draw is that the manual activity employed in these studies was not well planned and consequently not very involved. In contrast, the present study prescribed very specific tactile-kinesthetic sequences to be performed with the intent of familiarizing Ss to all relevant physical characteristics of the training stimuli. The impact of sensory-motor training in the present study was reflected even beyond the scope of the dependent measures being taken.

Subjects assigned to Condition 3 were often observed to imitate the tactile-kinesthetic sequences they received in training by repeating some of these same sequences on the assessment tasks, for examples by constructing imaginary lines with their fingers to represent an equilateral triangle. The form of manual activity used in the present study is more closely associated to the "practical exercises" emphasized by Soviet researchers (see Yendovitskaya, et. al., 1971) and Montessori (1964).

Another plausible explanation for contradictory findings may be related to the tasks used to assess the effects of training. The present study represents one of the few attempts at examining the role of sensory-motor activity in the context of children's concept learning and development. The concept tasks which were administered, particularly at the concrete and identity levels, required very fine types of discrimination between target and nonexamples. On the concrete tasks, the target was always varied from each nonexample according to one characteristic--on the basis of some value of either shape (equilateral triangle, right isosceles triangle, square), color (blue, red, yellow), size (large, small), or thickness (thick, thin). The identity task required not only careful discrimination but also an identification of the target (i.e., positive instance of the concept) in a different perspective or skewed orientation. In the second stimulus display the target was displaced in distance, rotated 180°, placed upright on its base, and placed upright with only a side being visible. Thus, when the treatment consisted of visually inspecting the training stimuli alone as in Condition 1, Ss seemed unprepared in making the later discriminations and identifications required on the concrete and identity trials, even when the amount of time had been equalized for the various treatment conditions.

One of the more surprising results of the present investigation was that manual activity even benefited concept attainment for the 5-year-olds. As it was hypothesized earlier, manual activity was expected to be facilitating only for the 3-year-olds. In view of the level of difficulty underlying the concrete and identity tasks and in view of the complexity of stimuli being employed, it may have been the case that even some of the 5-year-old Ss had to depend on manipulative experience as a means of gaining some sense of familiarity with the stimuli.

The second most important discovery of this study, already mentioned above, concerns the role of verbal orienting instruction. In general, the combining of verbal instruction with manipulation and visual activity represented the most effective treatment for the three levels of concept attainment. Similar results have been obtained by Luria (1961) in an object form recognition task with 3- and 4-year-old Ss (see p. 27). The influence of verbal orienting instruction in Condition 4 (as well as in Condition 2) was especially apparent at the classificatory level, perhaps because Ss had a better understanding of the word "shape" as a result of training. This finding is in accord with the CLD model as stated by Klausmeier, Ghatala, and Frayer (in press), which holds that as a child attains successively higher levels of the same concept he depends increasingly on verbal functions. Facilitation by means of verbal instruction, however, cannot be so easily reconciled with the cognitive developmental views of Piaget, who has always argued that language plays a limited role in the formation of the child's thought. Piaget feels that intellectual development is derived from action and is primarily non-verbal. And yet, while Piaget de-emphasizes the regulatory role of language, one must carefully distinguish between the Piagetian approach to the study of intellectual development, which concentrates primarily on the operative aspect of thought (i.e., logico-mathematical knowledge--the internalization of cognitive strategies), and other approaches. Concept learning and development, as viewed by Klausmeier, et al. (in press), is substantially the study of how the child comes to acquire knowledge of his world and how this knowledge is organized. The CLD approach to the study of intellectual development is thus very different from the logico-mathematical model of Piaget. By bearing this distinction in mind, it may be that concept formation is more amenable to language influence while the evolution of cognitive structures in Piaget's system is not.

Thirdly, one of the most interesting results of the entire study from the standpoint of the CLD model was the interaction between age and treatment. Age x treatment interactions occurred on the concrete level task used in measuring far transfer (two-dimensional geometric forms) and on the two identity level tasks used in measuring near and far transfer (geometric blocks and two-dimensional geometric forms). As it was pointed out previously, 3-year-old Ss had a greater tendency to depend on manual exploratory activity than 5-year-old Ss, who in turn had a greater tendency to depend on verbal orienting instruction. This finding is of particular significance to the CLD model since Klausmeier, et al. (in press) have stated that with increasing age children begin using language as a vehicle for acquiring concepts. This finding is also consistent with Soviet psychologists and, in particular, the two signaling system hypothesis which holds that the language mechanism or verbal functions gradually supplant sensory-motor functions with increasing age.

Although the age x treatment interactions were marginally significant, it is quite plausible that this result would have been more clearly defined if Ss were stratified differently according to age. If stratification was carried out with 3- and 7-year-olds, for example, the differential effects of Conditions 2 and 3 and of Conditions 2 and 4 would have been more revealing. These relationships might be further explored in a future study.

Lastly, it is important to note the extent of generalizability of training in the present study. Recall that Ss were assessed for transfer of training at two levels: (1) near transfer in the test of concept attainment using training materials as test stimuli, and (2) far transfer in the test of concept attainment using two-dimensional geometric representations. Training was transferable to both of these levels. The success of far transfer in case (2) has particular theoretical significance in this study since it clearly demonstrates that training with physical objects can influence subsequent performance with the use of representational material (i.e., two-dimensional drawings). To the best of the author's knowledge there have been no previous findings reported of this kind.

Educational Implications

While the present experiment yielded many interesting results, it is important to determine the effects of intervention from the standpoint of the young child. Clearly, sensory-motor training and verbal orienting instruction facilitated the child's level of concept attainment of equilateral triangle at the concrete, identity, and classificatory levels. For example, on the classificatory task using geometric blocks, 67% of the 3-year-old Ss were able to classify equilateral triangles correctly on at least one trial given the benefit of this training, whereas only 5% of the 3-year-old Ss (or 1 child) in the visual and control conditions were able to duplicate this feat. Ninety percent of the 5-year-old Ss who were administered some form or combination of sensory-motor training and verbal orienting instruction were able to classify at least one trial correctly, while only 30% of the 5-year-old Ss could do this in the visual or control groups. Of practical significance to early childhood education, it is noteworthy to find that 3-year-old children can understand verbal instruction and can derive actual benefits from it.

The effects of intervention are particularly evident from the data in Table 23 which were obtained from the concrete and identity tasks. Reaction times for Ss in the sensory-motor and verbal conditions (Conditions 2, 3, and 4) were considerably longer than RTs for Ss in either the visual (Condition 1) or the control (Condition 5) groups. On the basis of this data it seems reasonable to conclude that Ss who who were given the benefit of either sensory-motor training or verbal orienting instruction or a combination of the two were inhibited in making impulsive responses. This is not true, of course, for the visual and control groups where RTs were longer. Interpreted another way, it seems that by supplementing visual activity the effect was to help guide and maintain the child's visual attention toward relevant characteristics of the stimuli.

Summary

The purpose of this study was to ascertain the effects of various forms and combinations of sensory-motor training and verbal orienting instruction in early concept acquisition. The concept identified was that of equilateral triangle. One hundred children of 3- and 5-years of age were assessed for their knowledge of the concept at the concrete, identity, and classificatory levels. Each of these subjects were given preliminary training in one of the following groups:

(1) visual inspection

(2) visual inspection + verbal orienting instruction

(3) visual inspection + free haptic activity + tactile-kinesthetic training

(4) visual inspection + free haptic activity + tactile-kinesthetic training + verbal orienting instruction

(5) unrelated play activity (control)

Subjects in Conditions 1-4 were trained with 36 geometric blocks varying in shape, color, size, and thickness. These materials represented examples and nonexamples of the concept of equilateral triangle. Subjects in Condition 5 were given pictures and crayons. The experimental design was a 2 x 2 x 5 factorial with age (three or five), sex (boy or girl), and treatment (Conditions 1, 2, 3, 4, or 5) included as factors. The dependent measures consisted of tasks based on previous studies by Frayer, Klausmeier, and Nelson (1973) and Klausmeier, Sipple, and Frayer (in press), which were used to assess attainment of the concept of equilateral triangle at the concrete, identity, and classificatory levels. The tasks were administered in two parts for assessing: (1) near transfer of training using the training materials as test stimuli, and (2) far transfer of training using two-dimensional representations of geometric forms. Each task was scored according to the total number of correct responses.

The results indicted that the mean number of correct responses on each of the concept tasks was significantly higher in Conditions 2, 3, and 4 than in Conditions 1 and 5. The combination of manual activity and verbal orienting instruction with visual exploratory behavior (Condition 4) was relatively more facilitating than any of the other four treatment groups. Five-year-old Ss had a higher mean number of correct responses than 3-year-old Ss. Marginal results were obtained in the age x treatment interaction for the concrete and identity tasks. Three-year-olds appeared to do relatively better than the 5-year-olds as a result of manual exploratory kinds of activity, while 5-year-olds appeared to do relatively better than the 3-year-olds as a result of verbal orienting instruction.

Appendix A

<u>Assessment Battery Concept Development I</u>:

<u>Equilateral Triangle</u>

(Two-Dimensional Geometric Forms)

Name ______________________________ Birthdate __________________
Last First Middle Month Day Year

School ____________________ Grade ____________ Today's Date ________

Concept Development IA

Klausmeier, H. J., Ingison, L. J., Sipple, T. S., and Katzenmeyer, C. G.

DO NOT TURN THE PAGE UNTIL YOU ARE TOLD TO DO SO.

COLOR KEY

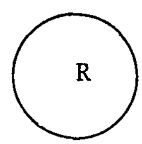
Blue = B

Red = R

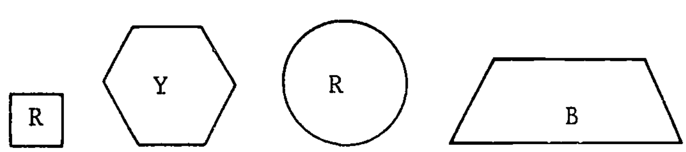
Yellow = Y

CONCRETE LEVEL

A. Practice Trial

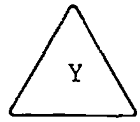


Stop

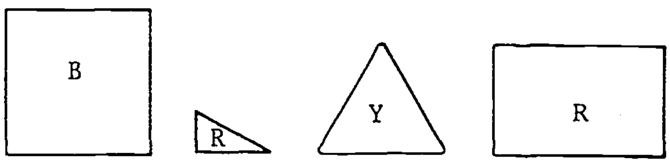


Stop

1.



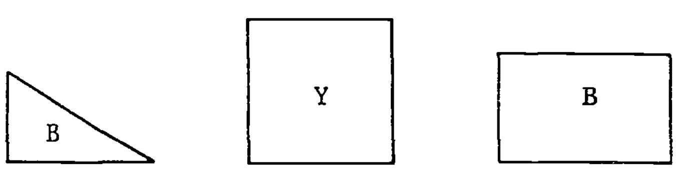
Stop

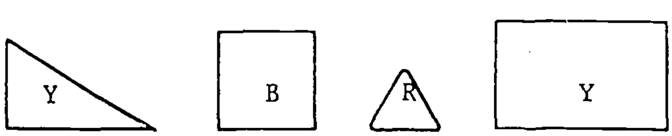


Stop

2.

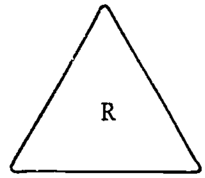
Stop



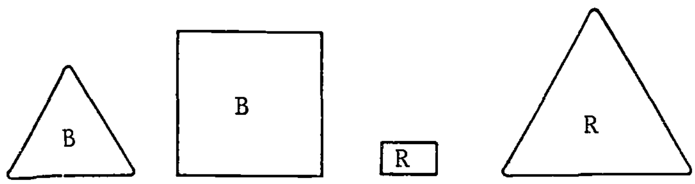


Stop

3.

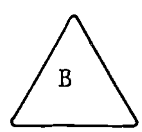


Stop

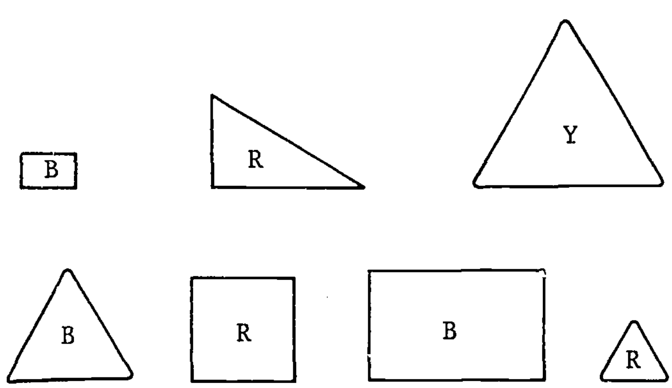


Stop

4.



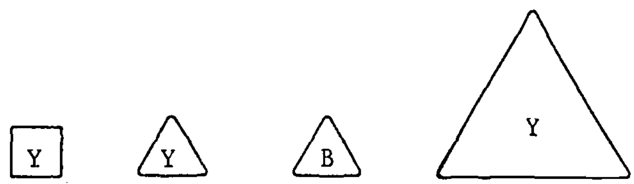
Stop



Stop

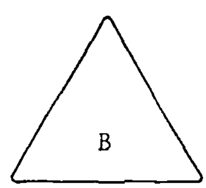
5.

Stop

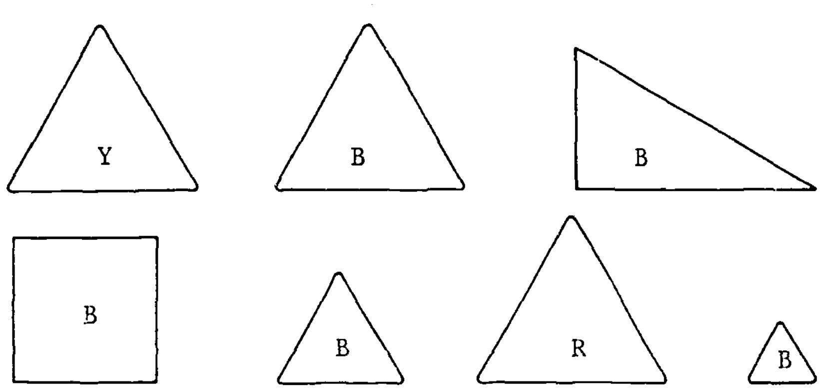


Stop

6.

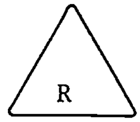


Stop

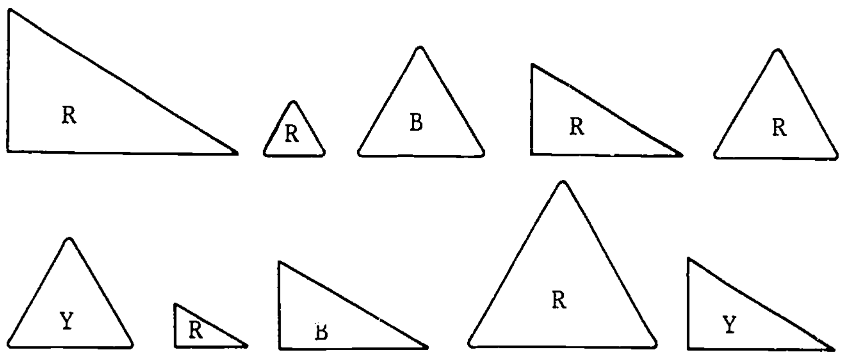


Stop

7.



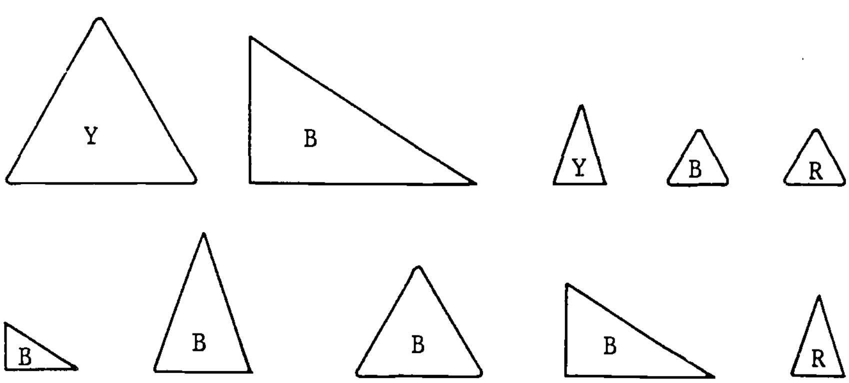
Stop



Stop

8.

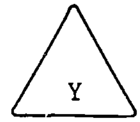
Stop



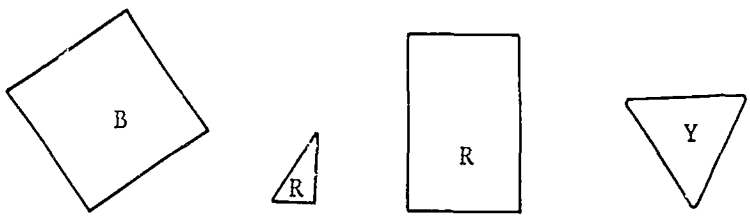
Stop

IDENTITY LEVEL

1.



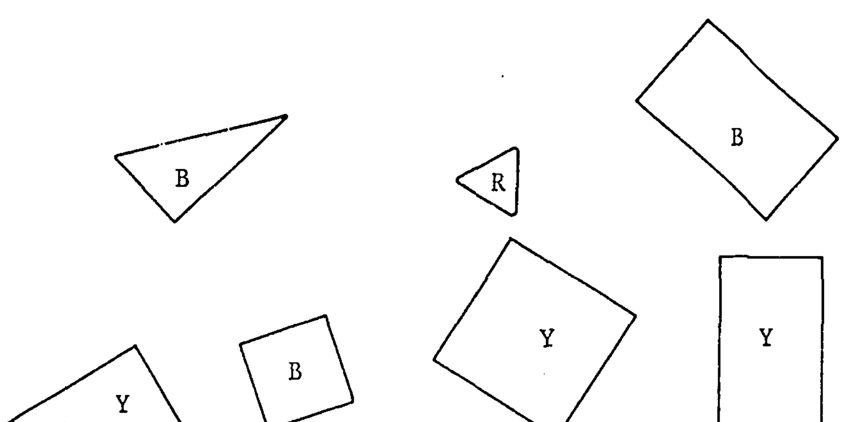
Stop



Stop

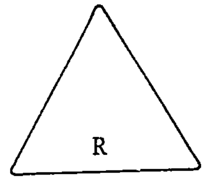
2.

Stop

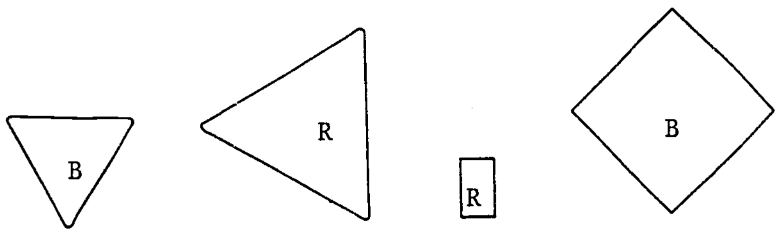


Stop

3.

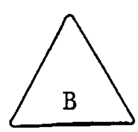


Stop

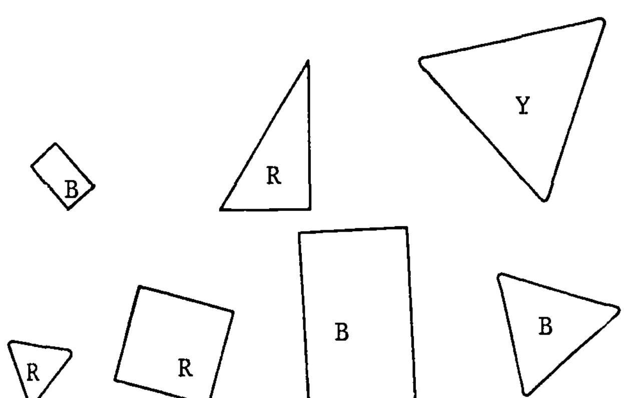


Stop

4.



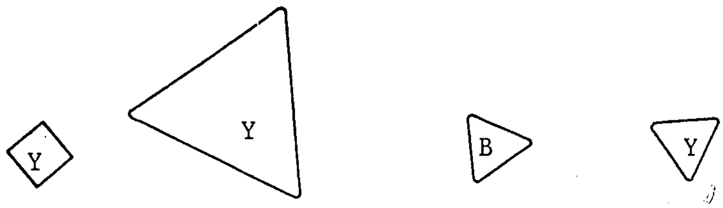
Stop



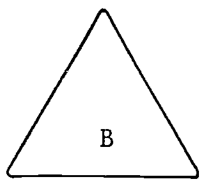
Stop

5. 

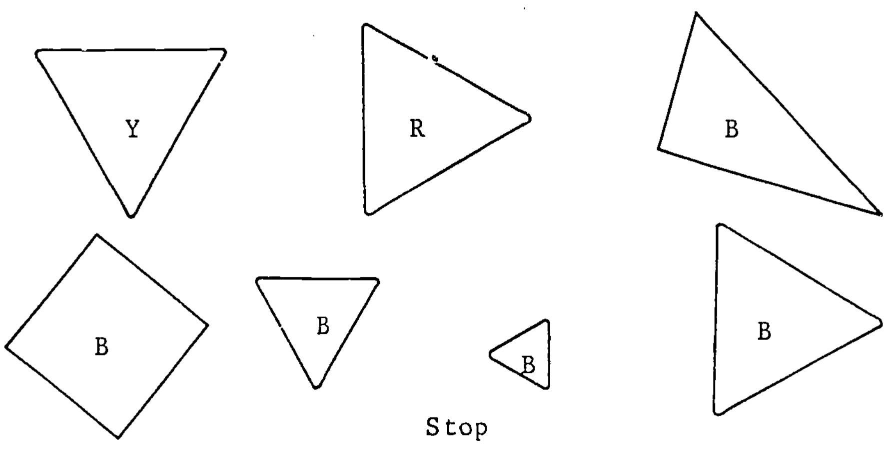
Stop



Stop

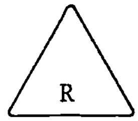
6. 

Stop

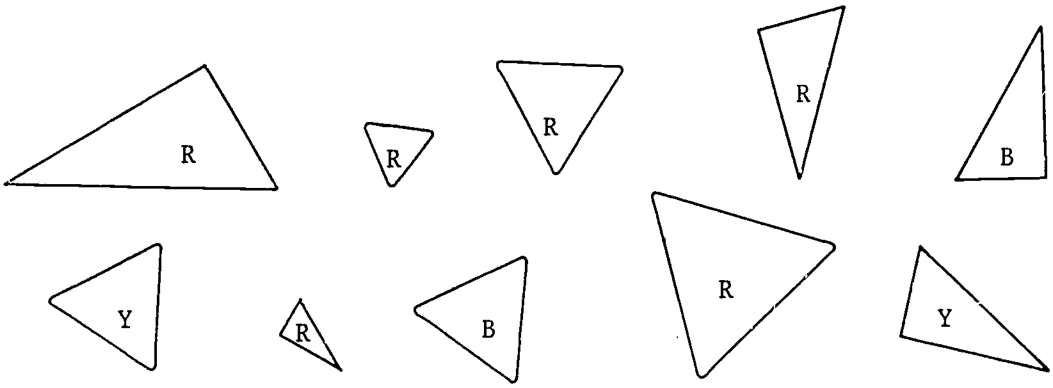


Stop

7.

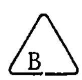


Stop

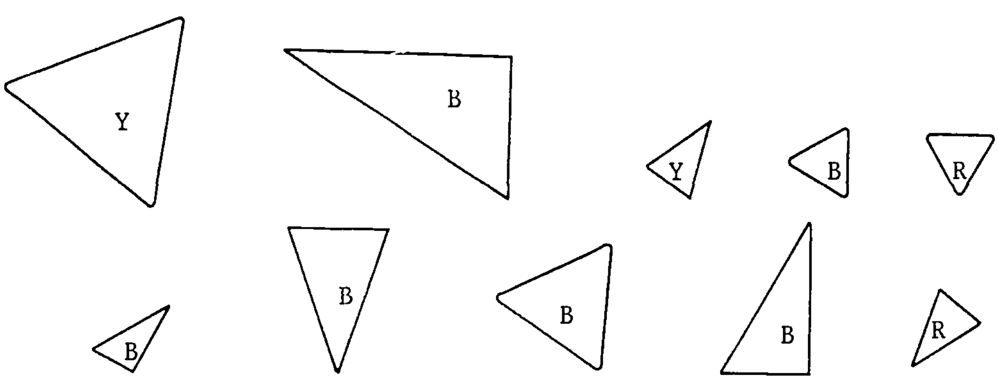


Stop

8.



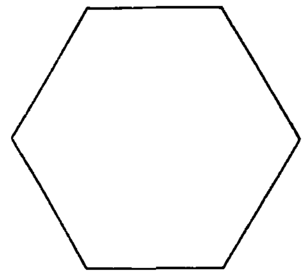
Stop



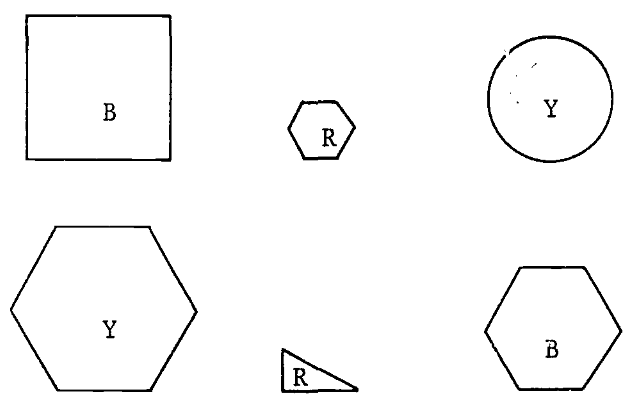
Stop

CLASSIFICATORY LEVEL

A. Practice Trial

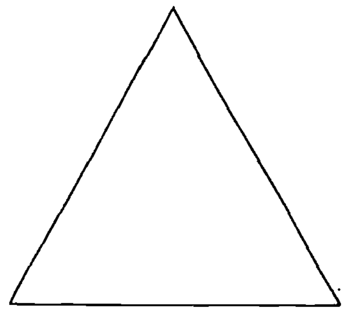


Stop

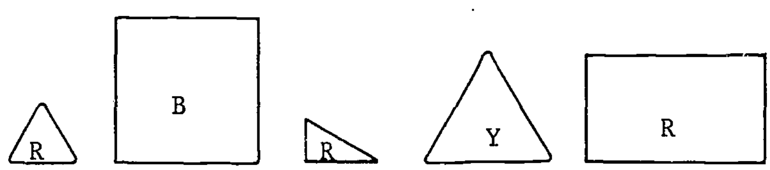


Stop

1.

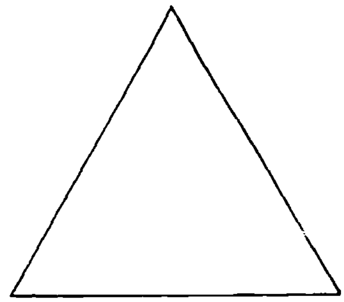


Stop

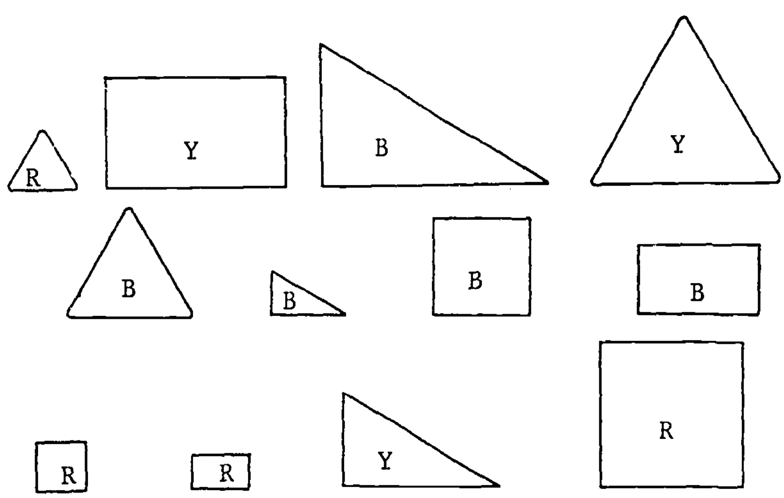


Stop

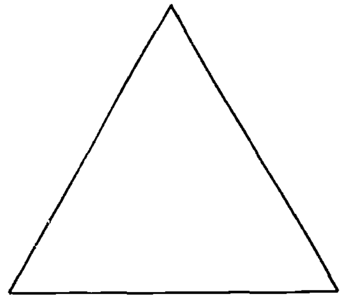
2.



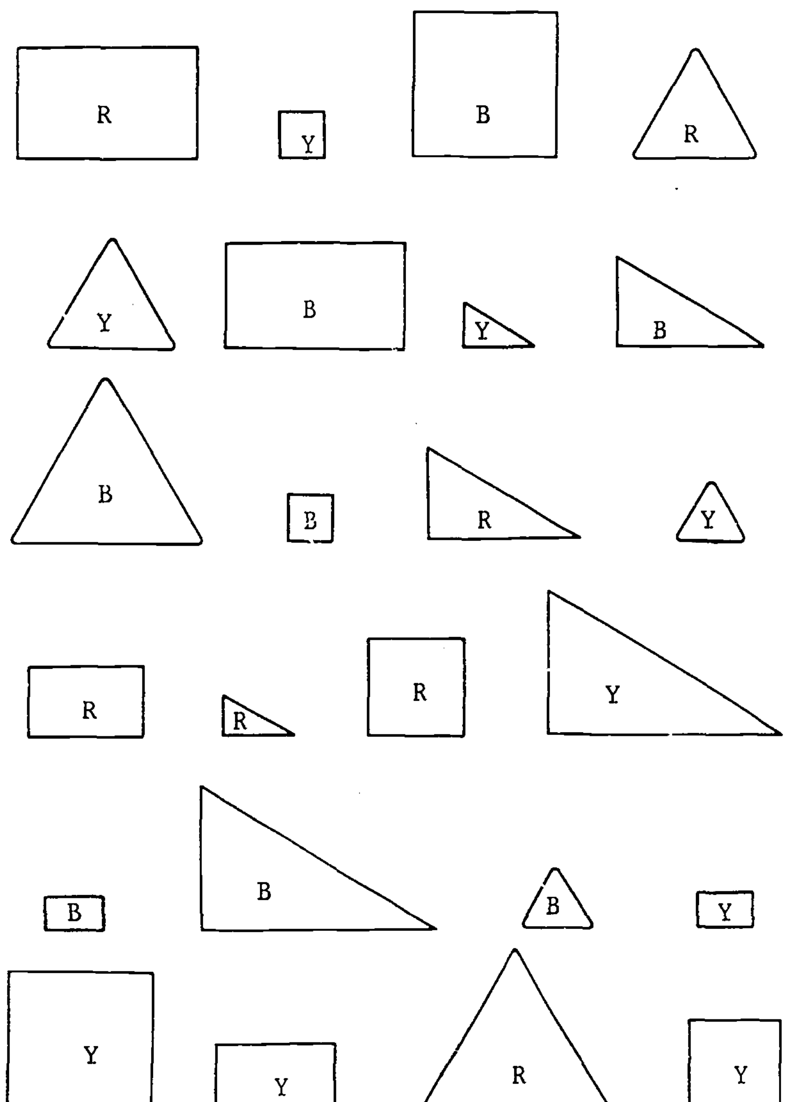
Stop



Stop

3. 

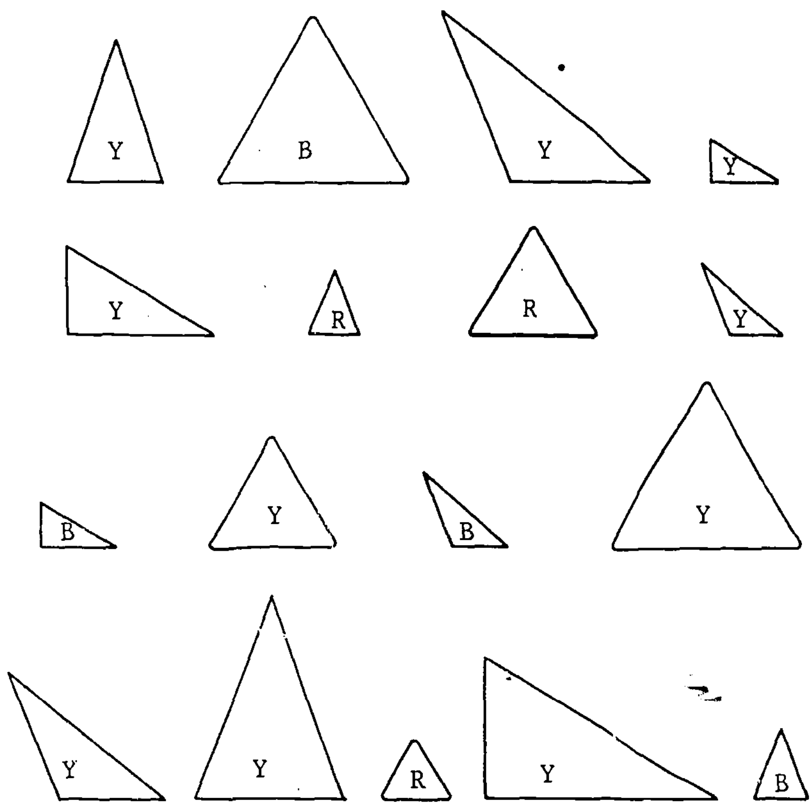
Stop



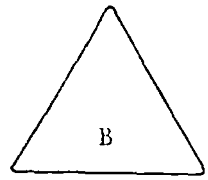
Stop

4.

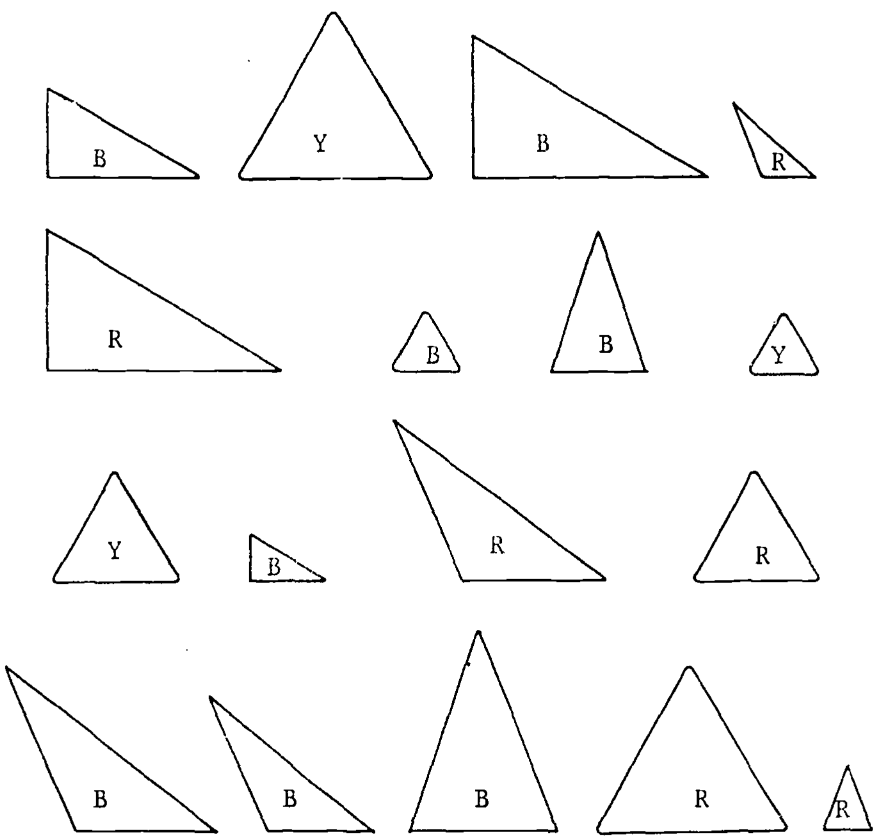
Stop



Stop

5. 

Stop



Stop

Appendix B

Response Data for Concrete, Identity, and Classificatory Tasks Using Geometric Blocks

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 3	1	0	0	0	1	0	0	0	0	0	0	0	0
Male	2	0	0	0	0	0	0	0	0	0	0	0	0
Condition 1	3	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0
	5	1	0	0	0	1	0	0	0	0	0	0	0
Age 3	6	0	0	0	0	0	0	0	0	0	0	0	0
Female	7	0	0	0	0	0	0	0	0	0	0	0	0
Condition 1	8	1	1	0	0	1	0	0	0	1	0	0	0
	9	0	0	1	0	0	1	0	0	0	0	0	0
	10	0	0	0	0	0	1	0	0	0	0	0	0
Age 3	11	1	1	1	1	1	1	1	1	1	1	1	1
Male	12	0	0	0	0	0	1	0	1	0	0	0	0
Condition 2	13	1	0	1	0	1	1	0	0	1	1	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	1	0	0	0	0	0	0	0	0	0
Age 3	16	0	0	0	0	0	0	0	0	1	1	1	0
Female	17	1	1	1	0	0	0	1	0	0	0	0	0
Condition 2	18	1	1	0	1	0	0	0	1	1	0	0	0
	19	1	1	0	0	0	1	0	1	1	1	1	0
	20	0	1	1	1	1	1	1	1	1	1	1	1

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 3	21	0	1	0	1	0	1	0	1	0	0	0	0
Male	22	1	1	1	0	0	0	1	0	1	0	0	0
Condition 3	23	1	1	1	1	1	1	1	0	1	1	1	0
	24	1	1	0	0	1	1	0	0	1	0	0	0
	25	1	1	1	0	1	1	0	0	1	1	0	0
Age 3	26	0	1	0	0	0	0	1	0	0	0	0	0
Female	27	1	1	0	1	0	1	0	1	1	1	1	0
Condition 3	28	0	1	0	0	0	0	0	0	0	0	0	0
	29	1	0	1	0	1	1	1	0	0	0	0	0
	30	1	1	0	0	0	1	0	0	0	0	0	0
Age 3	31	1	1	1	1	0	1	1	1	0	1	0	0
Male	32	1	0	0	0	1	1	0	1	1	1	1	1
Condition 4	33	1	1	0	0	1	1	1	0	1	1	1	0
	34	1	0	0	0	0	1	0	0	1	1	1	0
	35	1	1	1	0	1	1	1	0	1	1	1	1
Age 3	36	1	1	0	0	1	1	1	0	1	1	0	0
Female	37	0	1	1	0	1	1	1	1	1	1	1	1
Condition 4	38	1	0	1	0	1	1	0	0	1	0	0	0
	39	1	1	1	1	1	1	1	1	1	1	1	1
	40	0	1	0	1	0	1	0	0	0	0	0	0

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 3	41	1	0	0	0	0	1	1	0	0	0	0	0
Male	42	0	0	0	0	0	0	0	0	0	0	0	0
Condition 5	43	0	0	0	0	0	0	0	0	0	0	0	0
	44	0	0	1	0	0	1	0	0	0	0	0	0
	45	0	0	0	0	0	0	0	0	0	0	0	0
Age 3	46	0	0	0	0	0	0	0	0	0	0	0	0
Female	47	1	0	0	0	0	0	1	0	0	0	0	0
Condition 5	48	0	0	0	0	0	0	0	0	0	0	0	0
	49	1	0	0	0	0	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0	0	0	0	0	0

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 5	51	0	1	0	0	0	0	0	0	0	0	0	0
Male	52	0	0	0	0	0	1	0	0	0	0	0	0
Condition 1	53	1	1	1	1	1	1	0	0	1	1	1	0
	54	0	0	0	1	0	0	0	0	0	0	0	0
	55	1	1	0	1	0	1	1	1	0	0	0	0
Age 5	56	1	1	1	1	1	1	1	1	0	0	0	0
Female	57	0	1	1	0	1	1	0	0	1	0	0	1
Condition 1	58	1	1	0	1	0	1	1	1	1	0	0	0
	59	1	1	1	0	1	1	0	1	0	0	0	0
	60	1	1	1	1	1	1	1	1	1	0	0	0
Age 5	61	0	1	0	0	1	1	1	0	1	0	0	0
Male	62	1	1	1	0	1	1	1	0	1	1	1	1
Condition 2	63	1	1	1	0	1	1	1	0	0	0	0	0
	64	1	1	1	1	1	1	1	1	1	1	0	1
	65	1	1	1	1	1	1	1	0	1	0	0	0
Age 5	66	1	1	1	0	1	1	1	1	1	1	1	1
Female	67	1	1	1	1	1	1	1	1	1	1	1	1
Condition 2	68	1	1	1	0	1	1	1	0	1	1	1	1
	69	1	1	1	1	1	1	1	0	1	1	1	1
	70	1	1	0	0	1	1	1	1	1	1	0	0

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 5	71	0	1	0	1	1	1	1	0	0	0	0	0
Male	72	1	1	1	1	1	1	1	0	1	1	1	1
Condition 3	73	1	1	1	0	1	1	1	1	1	1	1	1
	74	1	1	0	1	1	1	0	0	0	0	0	0
	75	1	1	0	1	1	1	1	0	1	0	0	0
Age 5	76	1	1	1	1	1	1	1	1	1	1	1	1
Female	77	1	1	0	1	0	1	0	0	0	1	0	1
Condition 3	78	1	1	1	0	1	1	1	1	1	1	1	1
	79	1	1	1	1	1	1	1	0	1	0	1	1
	80	1	1	1	0	1	1	1	0	1	1	0	0
Age 5	81	1	1	1	1	1	1	1	1	1	1	1	1
Male	82	1	1	1	1	1	1	0	1	1	1	1	0
Condition 4	83	0	1	1	1	1	1	1	0	1	1	1	1
	84	1	1	1	1	1	1	0	0	1	1	1	1
	85	1	1	1	1	0	1	1	0	1	1	1	0
Age 5	86	1	1	1	1	1	1	1	1	1	1	1	1
Female	87	1	1	1	1	1	1	1	1	1	1	1	0
Condition 4	83	1	1	1	1	0	1	1	1	1	1	0	0
	89	1	1	1	0	0	1	1	0	1	1	1	1
	90	1	1	1	1	1	1	0	0	1	1	0	0

Treatment Group	S	Concrete Trials				Identity Trials				Classificatory Trials			
		1	2	3	4	1	2	3	4	1	2	3	4
Age 5	91	0	1	1	0	1	1	1	0	0	0	0	0
Male	92	1	1	0	0	0	1	0	0	0	0	0	0
Condition 5	93	0	1	0	1	0	1	1	1	0	0	0	0
	94	0	1	1	0	1	0	1	1	0	0	0	0
	95	0	1	1	1	1	0	0	1	1	0	0	0
Age 5	96	0	1	1	0	1	1	1	0	1	1	1	0
Female	97	0	1	1	0	1	1	0	0	0	0	0	0
Condition 5	98	1	1	1	1	0	1	1	1	0	0	0	0
	99	0	1	1	0	1	1	1	1	0	0	0	0
	100	1	1	1	1	1	1	0	1	0	0	0	0

Appendix C

Response Data for Concrete, Identity, and

Classificatory Tasks Using Two-Dimensional Geometric Forms

Treatment Group	S	Concrete Trials								Identity Trials								Classificatory Trials				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Age 3	1	1	0	1	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0
Male	2	1	1	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Condition 1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	1	1	1	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0
Age 3	6	1	1	0	1	1	0	0	0	1	1	1	0	1	0	0	0	1	1	0	0	0
Female	7	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0
Condition 1	8	1	1	0	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0
	9	1	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0
	10	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Age 3	11	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	0
Male	12	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Condition 2	13	1	1	1	1	1	0	1	0	1	1	1	0	1	0	0	0	1	1	0	0	0
	14	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	1	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Age 3	16	0	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0
Female	17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Condition 2	18	1	1	0	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0
	19	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1	0
	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0

Treatment Group	S	Concrete Trials								Identity Trials								Classificatory Trials				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Age 3	21	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0
Male	22	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Condition 3	23	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0
	24	1	1	1	1	0	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0
	25	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Age 3	26	1	1	1	0	1	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0	0
Female	27	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1	1	0	0	1	0
Condition 3	28	1	0	1	0	0	1	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0
	29	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0
	30	0	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0
Age 3	31	1	1	0	1	1	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0
Male	32	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	0	1	0
Condition 4	33	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0
	34	1	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	1	1	0	1	0
	35	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0
Age 3	36	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0
Female	37	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
Condition 4	38	1	0	1	0	1	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0
	39	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0
	40	0	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0

Treatment Group	S	Concrete Trials								Identity Trials								Classificatory Trials				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Age 3	41	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Male	42	1	1	1	0	1	1	0	1	1	0	1	0	1	0	1	0	1	0	0	0	0
Condition 5	43	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
	44	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0
	45	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Age 3	46	1	0	1	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0
Female	47	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Condition 5	48	1	0	0	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0
	49	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
	50	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0

Treatment Group	S	Concrete Trials 1	2	3	4	5	6	7	8	Identity Trials 1	2	3	4	5	6	7	8	Classificatory Trials 1	2	3	4	5
Age 5	51	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0
Male	52	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Condition 1	53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
	54	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
	55	1	1	1	1	1	0	0	1	1	0	1	1	0	1	1	1	0	0	0	0	0
Age 5	56	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Female	57	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
Condition 1	58	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	0	1	0	[illegible]	0
	59	1	1	1	0	1	1	0	1	1	1	1	1	1	0	1	1	0	1	1	[illegible]	0
	60	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	[illegible]	0
Age 5	61	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Male	62	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
Condition 2	63	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0
	64	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
	65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Age 5	66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	[illegible]	0
Female	67	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	[illegible]	0
Condition 2	68	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1
	69	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0
	70	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1

Treatment Group	S	Concrete Trials								Identity Trials								Classificatory Trials				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Age 5	71	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1	1
Male	72	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Condition 3	73	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
	74	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	0	0	0
	75	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	0	0
Age 5	76	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
Female	77	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1
Condition 3	78	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0
	79	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0	1
	80	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Age 5	81	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Male	82	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1
Condition 4	83	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	84	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1
	85	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
Age 5	86	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Female	87	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0
Condition 4	88	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0
	89	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
	90	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0

Treatment Group	S	Concrete Trials								Identity Trials								Classificatory Trials				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5
Age 5	91	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0
Male	92	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0
Condition 5	93	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0
	94	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1
	95	1	1	1	1	1	1	0	1	1	1	1	0	1	1	0	0	1	0	0	0	0
Age 5	96	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	0	0	1
Female	97	1	1	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Condition 5	98	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0
	99	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0
	100	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0

References

Abravanel, E. How children combine vision and touch when perceiving the shape of objects. Perception & Psychophysics, 1972, 12, 171-175.

Balter, L., & Fogarty, J. Intra- and intersensory matching by nursery school children. Perceptual and Motor Skills, 1971, 33, 467-472.

Berkeley, G. A new theory of vision. London: J. M. Dent, 1910.

Bower, T. G. R. The visual world of infants. Scientific American, 1966, 215, 80-92.

Bower, T. G. R., Broughton, J. M., & Moore, M. K. The coordination of visual and tactual input in infants. Perception & Psychophysics, 1970, 8(1), 51-53.

Bronfenbrenner, U. Two worlds of childhood: U.S. and U.S.S.R. New York: Simon and Schuster, 1972.

Brozek, J., & Slobin, D. I. (Eds.) Psychology in the USSR: An historical perspective. New York: International Arts and Sciences Press, 1972.

Bruner, J. S. The course of cognitive growth. American Psychologist, 1964, 19, 1-15.

Bruner, J. S. Organization of early skilled action. Child Development, 1973, 44, 1-11.

Butter, E. J., & Zung, B. A developmental investigation of the effect of sensory modality on form recognition in children. Developmental Psychology, 1970, 3, 276.

Cashdan, S. Visual and haptic form discrimination under conditions of successive stimulation. Journal of Experimental Psychology, 1968, 76, 215-218.

Chalfant, J. C., & Scheffelin, M. A. Central processing dysfunctions in children: A review of research (NINDS, No. 9) Washington, D. C.: U.S. Dept. of Health, Education, and Welfare, 1969.

DeLeon, J. L., Raskin, L. M., & Gruen, G. E. Sensory-modality effects on shape perception in preschool children. Developmental Psychology, 1970, 3, 358-362.

Denner, B., & Cashdan, S. Sensory processing and the recognition of forms in nursery-school children. British Journal of Psychology, 1967, 58, 101-104.

Ellis, H. C. The transfer of learning. New York: Macmillan, 1965.

Finn, J. D. Multivariance - univariate and multivariate analysis of variance and covariance: A FORTRAN IV program. Version 4. Buffalo: Department of Educational Psychology, State University of New York at Buffalo, June 1968.

Frayer, D. A. Klausmeier, H. J., & Nelson, G. K. Pilot study of tasks to assess levels of mastery of the concepts Equilateral Triangle and Cutting Tool. Working Paper from the Research and Development Center for Cognitive Learning, University of Wisconsin, 1973, No. 111.

Furth, H. G. Thinking without language: Psychological implications of deafness. New York: Free Press, 1966.

Furth, H. Piaget and knowledge: Theoretical foundations. New Jersey: Prentice Hall, 1969.

Furth, H. G. Linguistic deficiency and thinking: Research with deaf subjects 1964-1969. Psychological Bulletin, 1971, 76, 58-72.

Furth, H. G. Further thoughts on thinking and language. Psychological Bulletin, 1973, 79, 215-216.

Gesell, A., Ilg, F. L., & Bullis, G. E. Vision: Its development in infant and child. New York: Harper, 1949.

Gibson, E. J. Principles of perceptual learning and development. New York: Appleton-Century-Crofts, 1969.

Gibson, J. J. Observations on active touch. Psychological Review, 1962, 69, 477-491.

Ginsburg, H., & Opper, S. Piaget's theory of intellectual development: An introduction. New Jersey: Prentice Hall, 1969.

Halverson, H. M. Studies of the grasping response of early infancy. I, II, and III. Journal of Genetic Psychology, 1937, 51, 371-449.

Klausmeier, H. J. Cognitive operations in concept learning. Educational Psychologist, November, 1971.

Klausmeier, H. J., & Davis, J. K. Transfer of learning. In R. L. Ebel (Ed.), Encyclopedia of educational research. (4th ed.) London: Macmillan, 1969.

Klausmeier, H. J., Ingison, L., Sipple, T. S., Katzenmeyer, C. Assessment battery concept development I: Equilateral triangle. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1973.

Klausmeier, H. J., Sipple, T. S., & Frayer, D. A. An individually administered test to assess level of attainment and use of concept, Equilateral Triangle. Technical Report from the Research and Development Center for Cognitive Learning, University of Wisconsin, 1973, in press.

Klausmeier, H. J., Ghatala, E. S., & Frayer, D. A. Conceptual learning and development: A cognitive view. New York: Academic Press, in press.

Luria, A. R. The role of language in the formation of temporary connections. In B. Simon (Ed.), Psychology in the Soviet Union. Stanford: Stanford University Press 1957.

Luria, A. R. Speech and the regulation of behavior. New York: Liveright Publishing Corporation, 1961.

Luria, A. R., & Yudovich, F. Speech and the development of mental processes in the child. London: Staples Press, 1968.

McGraw, M. B. The neuromuscular maturation of the human infant. New York: Columbia University Press, 1943.

McHugh, R. B., & Ellis, D. S. The "postmortem" testing of experimental comparisons. Psychological Bulletin, 1955, 52, 425-428.

Millar, S. Visual and haptic cue utilization by preschool children: The recognition of visual and haptic stimuli presented separately and together. Journal of Experimental Child Psychology, 1971, 12, 88-94.

Miller, R. G. Jr. Simultaneous statistical inference. New York: McGraw-Hill, 1966.

Montessori, M. The Montessori method. New York: Schocken Books, 1964.

O'Connor, N. (Ed.) Recent Soviet psychology. New York: Liveright Publishing Corporation, 1961.

Pavolov, I. P. Selected works. Moscow: Foreign Languages Publishing House, 1955.

Piaget, J. The language and thoughtof the child. New York: Harcourt, Brace & World, 1926.

Piaget, J. Play, dreams, and imitation. New York: Norton, 1951.

Piaget, J. The origins of intelligence in children. New York: International Universities Press, 1952.

Piaget, J. The construction of reality in the child. New York: Basic Books, 1954.

Piaget, J. Le langage et les opérations intellectuelles. In P. Fraisse & Piaget (Eds.), Problèms de psycho-linguistique. Paris: Presses Universitaires de France, 1963.

Piaget, J. The psychology of intelligence. New Jersey: Littlefield and Adams, 1966.

Piaget, J. Mechanisms of perception. New York: Basic Books, 1969.

Piaget, J., & Inhelder, B. The child's conception of space. New York: Norton, 1967.

Piaget, J., & Inhelder, B. Mental imagery in the child. New York: Basic Books, 1971.

Pick, A. D., & Pick, H. L., & Thomas, M. L. Cross-modal transfer and improvement of form discrimination. Journal of Experimental Child Psychology, 1966, 3, 279-288.

Pick, H. L. Perception in Soviet psychology. Psychological Bulletin, 1964, 62, 21-35.

Pick, H. L., Pick, A., & Klein, R. E. Perceptual integration in children. In L. P. Lipsitt and C. C. Spiker (Eds.), Advances in child development and behavior. Vol. 3. New York: Academic Press, 1967, Pp. 191-223.

Rahmani, L. Soviet psychology: Philosophical, theoretical, and experimental issues. New York: International Universities Press, 1973,

Rock, I., & Victor, J. Vision and touch: An experimentally created conflict between two senses. Science, 1964, 143, 594-596.

Rock, I., & Harris, C. S. Vision and touch. Scientific American, 1967, 216, 96-104.

Ryan, T. A. Multiple comparisons in psychological research. *Psychological Bulletin*, 1959, *56*, 26-47.

Ryan, T. A. Significance test for multiple comparisons of proportions, variances, and other statistics. *Psychological Bulletin*, 1960, *57*, 318-328.

Ryan, T. A. The experiment as the unit for computing rates of error. *Psycholgical Bulletin*, 1962, *59*, 296-300.

Scheffé, H. A method for juding all contrasts in the analysis of variance. *Biometrika*, 1953, *40*, 87-104.

Simon, B. (Ed.) *Psychology in the Soviet Union*. Stanford: Stanford University Press, 1957.

Simon, B., & Simon, J. (Eds.) *Educational psychology in the U.S.S.R.* Stanford: Stanford University Press, 1963.

Sinclair de Zwart, H. *Acquisition du langage et développement de la pensée*. Paris: Dunod, 1966.

Sinclair de Zwart, H. Developmental psycholinguistics. In D. Elkind & J. H. Flavell (Eds.), *Studies in cognitive development: Essays in honor of Jean Piaget*. New York: Oxford University Press, 1969, Pp. 315-336.

Tukey, J. W. Comparing individual means in the analysis of variance. *Biometrics*, 1949, *5*, 99-114.

Vygotsky, L. S. *Thought and language*. Cambridge: M.I.T. Press, 1962.

Weiner, B., & Goodnow, J. J. Motor activity: Effects on memory. *Developmental Psychology*, 1970, *2*, 448.

Werner, H. *Comparative psychology of mental development*. New York: International Universities Press, 1948.

Wilson, W. A. A note on the inconsistency inherent in the necessity to perform multiple comparisons. Psychological Bulletin, 1962, 59, 296-300.

Wolff, P. The role of stimulus-correlated activity in children's perception. Technical Report from the Research and Development Center for Cognitive Learning, University of Wisconsin, 1972, No. 223.

Yendovitskaya, T. V., Zinchenko, V. P. & Ruzskaya, A. G. Development of sensation and perception. In A. V. Zaporozhets & D. B. Elkonin (Eds.), The psychology of preschool children. Cambridge: M.I.T. Press, 1971, Pp. 1-64.

Zankov, L. V. Combination of the verbal and visual in teaching. In B. Simon & J. Simon (Eds.), Educational psychology in the U.S.S.R. Stanford: Stanford University Press, 1963. Pp. 243-258.

Zaporozhets, A. V. Origin and development of conscious control of movements in man. In The central nervous system and behavior: Selected translations from the Russian medical literature. Bethesda, Maryland: U. S. Department of Health, Education, and Welfare, 1958. Pp. 1005-1022.

Zaporozhets, A. V. The development of perception in the preschool child. In P. H. Mussen (Ed.), European research in cognitive development. Monograph of the Society for Research in Child Development, 1965, 30 (Serial No. 100), 82-101.

Zaporozhets, A. V., & Elkonin, D. B. (Eds.) The psychology of preschool children. Cambridge: M.I.T. Press, 1971.

☆U.S.Government Printing Office: 1974 — 750-528/1038 Region 5-I

National Evaluation Committee

Helen Bain
Past President
National Education Association

Lyle E. Bourne, Jr.
Institute for the Study of Intellectual Behavior
University of Colorado

Sue Buel
Dissemination and Installation Services
Northwest Regional Educational Laboratory

Francis S. Chase
Professor Emeritus
University of Chicago

George E. Dickson
College of Education
University of Toledo

Chester W. Harris
Graduate School of Education
University of California

Hugh J. Scott
Consultant
National Evaluation Committee

H. Craig Sipe
Department of Instruction
State University of New York

G. Wesley Sowards
Dean of Education
Florida International University

Joanna Williams
Professor of Psychology and Education
Columbia University

Executive Committee

William R. Bush
Director, Program Planning and Management
Deputy Director, R & D Center

M. Vere DeVault
Professor
School of Education

Herbert J. Klausmeier
Principal Investogator
R & D Center

Joel R. Levin
Principal Investigator
R & D Center

Donald N. McIsaac
Associate Dean, School of Education
University of Wisconsin

Richard A. Rossmiller, Committee Chairman
Director
R & D Center

Len VanEss
Associate Vice Chancellor
University of Wisconsin–Madison

Dan Woolpert
Director, Management Systems
R & D Center

Faculty of Principal Investigators

Vernon L. Allen
Professor
Psychology

B. Dean Bowles
Associate Professor
Educational Administration

Frank H. Farley
Associate Professor
Educational Psychology

Marvin J. Fruth
Associate Professor
Educational Administration

John G. Harvey
Associate Professor
Mathematics

Frank H. Hooper
Associate Professor
Child Development

Herbert J. Klausmeier
V. A. C. Henmon Professor
Educational Psychology

Gisela Labouvie
Assistant Professor
Educational Psychology

Joel R. Levin
Associate Professor
Educational Psychology

L. Joseph Lins
Professor
Institutional Studies

James Lipham
Professor
Educational Administration

Wayne Otto
Professor
Curriculum and Instruction

Robert Petzold
Professor
Curriculum and Instruction

Thomas A. Romberg
Associate Professor
Curriculum and Instruction

Dennis W. Spuck
Assistant Professor
Educational Administration

Richard L. Venezky
Associate Professor
Computer Science

Larry M. Wilder
Assistant Professor
Communication Arts